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V.—OIL-SEEDS, OILS, FATS, AND WAXES.

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SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT. EDITED BY THE DIRECTOR.

V.—OIL-SEEDS, OILS, FATS, AND WAXES.

INTRODUCTION.

The materials dealt with in the present part of this series of Selected Reports include oil-seeds and fixed oils, fats, and waxes of vegetable or animal origin; essential oils (volatile oils) will be dealt with in a separate part.

OIL-SEEDS.—Most of the vegetable oils and fats of commerce are obtained by expression or extraction from the seeds of plants, though in a few cases, *e.g.*, olive oil, the oil is derived from the fruit pulp. The value of an oil-seed depends partly on the amount and nature of the fat or oil it contains, and partly on the composition of the residue left after the oil or fat has been expressed from the seed.

FIXED OILS AND FATS.—These consist chiefly of mixtures of glycerides of fatty acids, with, as impurities, small quantities of colouring matter and unsaponifiable matter. They are conveniently divided into the following four classes:

1. Drying oils.
2. Semi-drying oils.
3. Non-drying oils.
4. Fats.

1. *Drying Oils.*—These oils when exposed to light and air in thin layers "dry," forming tough films, which are generally transparent: such oils are consequently employed in the manufacture of paints and varnishes but are unsuitable for use as lubricants. Their "drying" properties are due to the presence of glycerides of unsaturated acids such as linolenic and linoleic acids, which undergo oxidation and other changes on exposure to air. They have iodine values (see p. 441) ranging from about 125 to 206 per cent. Generally speaking, the higher the iodine value of an oil the greater its drying power. Linseed oil is the most important member of this class.

2. *Semi-drying Oils.*—These oils "dry" only after prolonged exposure to light and air, and do not as a rule yield sufficiently hard and tenacious films to allow of their use in paint or varnish manufacture; they are generally unsuitable for lubrication and are chiefly utilised in the manufacture of soaps and candles, though some of them also find application for illuminating purposes and the best of them are also used as edible oils. The iodine values of oils of this class vary from about 94 to 125 per cent. Cotton seed and rape seed oils are important and typical members of this class.

3. *Non-drying Oils.*—These oils remain quite liquid on exposure to air and are consequently largely employed as lubricants; they are also used as edible oils and the poorer qualities are utilised in soap manufacture. All the important oils included in this group have iodine values of less than 100 per cent. The best-known member is olive oil, which has an iodine value of 79 to 88 per cent.

4. *Fats.* Such oils as are solid or semi-solid at ordinary European temperatures are often termed fats. It should be pointed out, however, that this distinction is difficult to maintain since a product such as palm oil is a semi-solid fat when imported to this country, but is liquid at the high temperatures prevailing in West Africa. Fats, with a few exceptions, have iodine values of less than 75 per cent.

The solid or semi-solid nature of fats is due to the predominance in them of glycerides of high melting point such as palmitin or stearin.

WAXES.—The waxes differ from the oils and fats in that the fatty acids are not combined with glycerol but with other alcohols, such as cetyl, ceryl or myricyl alcohol, no glycerides being present: thus beeswax consists principally of cerotic acid and myricin, a compound of myricyl alcohol and palmitic acid. These alcohols are insoluble in water, whilst glycerol is soluble, and consequently the waxes yield large quantities of "unsaponifiable matter." The waxes are generally solid bodies of harder consistence and higher melting point than the fats.

Methods of Investigation.

The following is a brief description of the methods of investigation employed for these products, with indications of the manner in which the results obtained may be interpreted:—

Examination of Oil-seeds.

In the case of samples of such oil-seeds as are already of commercial importance, the sample under examination is compared with standard commercial samples, differences in colour, average weight of seed, or freedom from dirt and foreign seeds being noted. In the case of new oil-seeds, examination of the structure of the seeds is made, as although seeds may contain oil in sufficient quantity to render them of commercial importance, the nature of the seed coat, such as a hard, thick or heavy shell, may prevent their commercial utilisation.

Estimation of Moisture.—A weighed portion of finely divided seed is dried at 100° C. In the case of oil-seeds containing drying oils the material is dried in a current of carbon dioxide, or other inert gas, to prevent errors arising from absorption of oxygen from the atmosphere by the oil. The quantity of moisture varies with the state of maturity of the seed and the conditions under which it has been prepared and stored. Its determination is of importance in order that the actual oil or fat content of the dry seed may be calculated, and comparable results for different samples obtained, free from the influence of such a variable factor as the moisture content.

Estimation of Oil or Fat.—A quantity of finely ground seed is placed in a Soxhlet extractor and extracted with light petroleum until free from oil; the solvent is then removed from the oil by evaporation, the last traces being got rid of by heating the oil to 100° C. *in vacuo* until it ceases to lose weight. Large laboratory samples of oil for examination are prepared by similar methods.

Examination of Oil

Preliminary.—Any peculiarities in appearance, such as colour or turbidity, and in taste are noted. The drying power is then tested by spreading a thin film of the oil on a glass plate and exposing to air in a warm place.

Previous to chemical examination any water or suspended matter in the oil is removed by heating and filtering the oil; in some cases moisture and dirt (suspended insoluble matter) are present in appreciable quantities and are then quantitatively estimated.

Specific Gravity.—In the case of liquid oils this constant is generally determined by comparison with water at 15.5° C.; with solid fats a higher temperature is employed, generally 99-100° C.

Acid Value.—The acid value is determined by titrating a weighed quantity of the oil or fat, mixed with pure neutral alcohol, with standard caustic potash (potassium hydroxide) solution, using phenolphthalein as indicator. The acid value is the number of milligrams of potassium hydroxide required to neutralise the free acids in 1 gram of the oil or fat.

Saponification Value.—To a weighed quantity of the oil is added a quantity of a standard alcoholic solution of caustic potash in excess of that required to completely convert the oil into soap. The liquid is then boiled until globules of oil are no longer visible, showing that saponification is complete, after which the excess of caustic potash is determined by titration with standard hydrochloric acid using phenolphthalein as indicator. The number of milligrams of caustic potash required to convert 1 gram of oil into soap is termed the "saponification value," and is constant, within certain limits, for each kind of oil.

Iodine Value by Hubl's Method.—A weighed quantity of the oil is dissolved in pure chloroform and allowed to stand over night (about 17 hours) with an excess of a standard alcoholic solution of iodine and mercuric chloride. The operation is carried out in a tightly stoppered bottle placed in a dark cupboard. At the end of 17 hours the excess of free iodine is estimated by titration with standard sodium thiosulphate solution in the usual manner.

The iodine value is expressed as the percentage by weight of iodine absorbed by the oil. This is a measure of the amount of unsaturated glycerides (*e.g.*, glycerides of linolenic and linoleic acids) contained in the oil, and, as already indicated, serves to distinguish "drying" from "semi-drying" or "non-drying" oils.

Hehner Value.—This indicates the percentage amount of insoluble fatty acids together with any unsaponifiable matter in the oil, and is determined by saponifying a weighed quantity of the oil with caustic potash. The fatty acids are liberated from the soap so formed by adding an excess of dilute sulphuric acid, then melted by heating, and washed with dilute sulphuric acid and finally with hot water on a thick filter paper until free from mineral acid. They are then dried at 100° C. and weighed.

Unsaponifiable Matter.—A weighed portion of the sample is saponified with caustic potash, and then extracted with ether, which removes the unsaponifiable matter together with some soap. The ethereal solution is then washed with water and dilute caustic potash, to remove any soap, dried with anhydrous sodium sulphate, evaporated to dryness, and the unsaponifiable matter left as a residue weighed. The result is expressed as a percentage of the oil or fat. Owing to difficulty in separating the unsaponifiable matter from the soaps, this estimation cannot be carried out with great accuracy. The unsaponifiable matter contains such substances as phytosterol in vegetable oils and cholesterol in animal fats, together with other bodies.

Titer Test.—This is the temperature at which the insoluble fatty acids solidify. The fatty acids, prepared as already described (see above), are dried and filtered into a test tube until this is about half filled with the melted fatty acids. The test tube is then fitted into a wide-mouthed bottle, to prevent rapid or uneven cooling by draughts of air a delicate thermometer is inserted in the liquefied acids, and when a few crystals appear at the bottom of the tube, the acids are carefully stirred and the temperature, in Centigrade degrees, noted from time to time. This at first falls, but later rises suddenly some tenths of a degree to a point at which it remains stationary for a short time before it again falls; this is the "titer" or solidifying point.

Reichert-Meissl Value.—This is a measure of the amount of volatile fatty acids contained in an oil, and is determined in the following manner: Five grams of fat are carefully saponified with excess of caustic potash dissolved either in alcohol or glycerol; the fatty acids are liberated by means of dilute sulphuric acid and the liquid distilled in such a way that 110 c.c.

distil over in about one hour. One hundred c.c. of this solution are filtered off and titrated with decinormal caustic potash solution, using phenolphthalein as indicator. The number of cubic centimetres of the standard alkali used multiplied by 1·1 is the "Reichert-Meissl" value. As it is impossible to completely separate the volatile from the non-volatile fatty acids this test must always be carried out under identical conditions. It is largely employed in the examination of butter for the presence of substitutes prepared from vegetable oils and fats.

As a general rule, the examination of the oils dealt with in this publication has been made with one of two objects in view, viz., (1) to ascertain the essential identity of the material with a known commercial product, or (2) to determine the nature of the oil and the class to which it belongs with a view to ascertaining to what industrial uses it can be applied, and consequently what its commercial value may be.

The results obtained in the various operations described above afford useful information as regards both these matters. The figures obtained in these determinations are usually fairly constant for a particular kind of oil, and therefore serve to identify a sample if the typical constants of that oil have been recorded previously.

In the case of an unknown oil the figures obtained in such determinations serve to indicate the class to which the oil belongs and the purposes to which it may be applied. Thus an oil with a high iodine value will probably dry well and be suitable for the manufacture of paints and varnishes. Oils containing more than traces of unsaponifiable matter are unsuitable for use as edible oils, as are also oils possessing an unpleasant flavour or dark colour, which cannot be removed by ordinary commercial refining processes. An oil with a high acid value would be unsuitable for use as a lubricant, as the free acids would be likely to cause corrosion of metallic surfaces. The "titer" test is a useful indication to the soapmaker of the consistence of the soap which an oil will yield.

The present part of Selected Reports from the Scientific and Technical Department of the Imperial Institute includes all the more important reports on oil-seeds, oils, fats and waxes made to Colonial, Indian and other Governments between January 1st, 1903, and December 31st, 1912. Most of the experimental work recorded has been conducted by various members of the staff of the Scientific and Technical Department, especially Mr. R. G. Pelly, F.I.C. The Imperial Institute is also indebted to a number of external experts and firms for conducting technical trials and giving valuations of these products. Among these may be mentioned especially Messrs. The British Oil and Cake Mills, Ltd.; Messrs. Joseph Crosfield and Sons, Ltd.; Messrs. Lever Bros., Ltd.; Messrs. J. Bibby and Sons, Ltd.; Messrs. The Hull Oil Manufacturing Co., Ltd.; Messrs. Lewis and Peat; Messrs. The Produce Brokers Co., Ltd.; and as well as the late Dr. Julius Lewkowitsch.

DRYING OILS.

The most important drying oil of commerce is linseed oil, derived from the seeds of the flax plant (*Linum usitatissimum*).

Tung oil (Chinese wood oil) derived from the seeds of species of *Aleurites* is also an important oil in this class, as can be seen from the following table showing the exports of this oil from Hankow in recent years:—

Tung Oil.

1907.	1908.	1909.	1910.	1911.
Tons	Tons.	Tons.	Tons	Tons.
23,539	35,093	27,506	45,057	35,083
£	£	£	£	£
539,811	648,576	471,728	868,321	785,318

The following materials belonging to this class have been examined and reported on:

Linseed (*Linum usitatissimum*).
Niger seed (*Guizotia oleifera*).
Hemp seed (*Cannabis sativa*)
Aleurites Fordii seed and oil
Aleurites triloba seed and oil.
Para rubber (*Hevea brasiliensis*) seed and oil.
Ceara rubber (*Manihot Glaziovii*) seed and oil
"Nsa-sana" (*Ricinodendron africanus*) seed and oil.

LINSEED.

The importance of this oil-seed may be judged from the fact that in 1910, 1,189,135 quarters (of 416 lb.), valued at £4,529,974, and in 1911, 1,393,874 quarters, valued at £4,728,536, were imported to the United Kingdom alone. At the present time linseed is quoted at about 42s. per quarter, and linseed oil at £22 per ton (Nov. 1913).

SUDAN.

This was a fine sample of linseed, which would command very good prices. Commercial experts stated that it would be worth 47*s*. 6*d*. per quarter, but that it would only realise this price in small quantities. It would, however, sell freely at about 44*s*. per quarter (current price, May, 1906).

EAST AFRICA PROTECTORATE.

This sample of linseed was described as "sown on the 21st April and reaped on the 22nd August." It was forwarded by the Director of Agriculture.

Commercial experts stated that it was of good quality and worth from 40*s*. to 42*s*. 6*d*. per quarter (December, 1905).

A further sample, grown near Gilgil, was received in April, 1912. This was also of very good quality, and was valued at 69*s*. per quarter for crushing (June, 1912).

NATAL.

This linseed was received in December, 1908. The sample consisted of rather large flat seed, showing a few perished grains but practically free from impurities.

The seed was submitted to commercial experts, who stated that it was of good quality, but out of condition, possibly owing to damp. They valued it (March, 1909) at £11 per ton, and added that to obtain this price it should be delivered in good condition in small lots of 50 to 100 tons. If delivered in quantities of 500 or 1,000 tons it would probably not realise more than £10 10*s*. per ton.

MAURITIUS.

This sample consisted of linseed in good condition, a very few foreign seeds and a small amount of shrivelled seed were present. The seeds yielded 38·4 per cent. of oil, compared with 32 to 42 per cent. recorded for commercial linseed. The oil had the usual appearance of linseed oil.

Linseed, represented by this sample, would realise the current price of the product if marketed in good condition, viz., 64*s*. to 72*s*. per quarter of 416 lb. (October, 1911).

For a detailed account of the cultivation and preparation of linseed and the uses of the seed and oil, see "*Bulletin of the Imperial Institute*" (1911, **9**, 355).

NIGER SEED.

EAST AFRICA PROTECTORATE.

This sample of Niger seed, *Guizotia* sp., was grown at the Kabete Experimental Farm. It contained 37·6 per cent. of oil, as compared with 40 to 45 per cent. in commercial Niger seed. The seed was submitted to oil manufacturers in the United Kingdom, who stated that both Niger seed oil and cake were well known products, but that very little of this seed was imported into the United Kingdom. If shipped regularly from East Africa it should have no difficulty in finding a market here.

The oil could be used as a substitute for linseed oil in making soft soap, and on that basis the seed was valued at 36*s*. to 38*s*. per quarter of 416 lb., ex ship Hull (September, 1909), but it was pointed out that it might fetch a higher price in Marseilles, where the seed is said to be employed for the manufacture of edible oil.

HEMP SEED.

HONG KONG.

This was a sample of small, greyish seeds with the usual appearance of hemp seed. A number of the seeds had been attacked by insects, and the sample contained over 2 per cent. of foreign grains, dust, &c.

The hemp seed, freed from the foreign grains, &c., yielded 28·2 per cent. of liquid yellowish-green oil, as against 30 per cent. obtained from hemp seed of average commercial quality.

The seed was submitted to a large firm of oil-seed crushers, who reported that it was dull, dirty, and small, and generally rather poor in quality, whilst the yield of oil was low, and the percentage of woody fibre high. They valued the sample at not more than £8 5s. per ton in Europe (February, 1912), against £9 to £9 10s. for ordinary good hemp seed. A firm of brokers stated that the seed was of inferior quality to that imported from Manchuria, and yielded less oil, and valued it at not over £9 per ton for crushing purposes (February, 1912), adding that a limited quantity might be sold as bird seed at £10 per ton.

TUNG OR CHINESE WOOD OIL.

(*Aleurites Fordii*).

HONG KONG.

The seeds of a species of Aleurites, since identified at Kew as *Aleurites Fordii*, Hemsl., were forwarded for examination to the Imperial Institute from Hong Kong in April, 1906.

It was stated that this species of Aleurites is one of the trees grown in China for the production of Chinese wood-oil (tung oil), and that it occurs in Fokien Province intermixed with *Aleurites cordata*, which was formerly considered to be the sole source of wood-oil. It was thought, therefore, that it would be of interest to have an examination made of the oil from the seeds of the new species, in order to determine its quality in comparison with that of the tung oil of commerce, which appears to be prepared indiscriminately from the seeds of *Aleurites cordata* or *Aleurites Fordii*, or mixtures of the two.

The sample consisted of two bags of nuts weighing 500 grams. The kernels of the nuts were fresh and in good condition on arrival.

On extraction with light petroleum, the kernels were found to contain 58·3 per cent. of oil, equivalent to a yield of 36·1 per cent. from the entire nuts. The oil was light in colour, and, on exposure to air in a thin layer, dried in a day at the ordinary temperature, giving a varnish-like residue. On heating in a water-oven at 100° C. the oil dried and formed a resin-like solid.

The "constants" of the oil were determined and found to agree well with those recorded for commercial samples of tung oil, as shown in the following table:—

	Oil from seeds of *A. Fordii*.	Commercial Tung oil.
Specific gravity at 15° C.	0·9401	0·933-0·942
Acid value	2·89	
Saponification value ...	191·8	190-197
Iodine value	166·7	149-165
Hehner value	94·6	96·3
Titer test	42°-42·5° C.	37·1°-37·2° C.

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* Since these reports were prepared for publication Mr E. H. Wilson has shown that the two Chinese species concerned are *Aleurites Fordii* Hemsl. and *A. montana* Wilson, and that the former yields practically all the Chinese wood-oil of commerce (*Bull. Imp. Inst.* 1913, 11., 441).

The oil extracted from the seeds of *Aleurites Fordii* is similar in composition to the tung oil of commerce. It is, however, lighter in colour, and produces a lighter-coloured varnish on drying, so that it is probably a purer product. It is noteworthy also that it has a higher titer test than commercial tung oil.

CANDLE NUTS (*Aleurites triloba*).

HONG KONG.

A sample of the seeds of *Aleurites triloba*, Forst., was forwarded for examination to the Imperial Institute by the Superintendent of the Botanical and Forestry Department, who stated that it is one of the best shade trees in Hong Kong, and that it grows very quickly.

The seeds of this tree which is frequently referred to in technical literature as *Aleurites moluccana*, given as a synonym for *A. triloba* in the Index Kewensis, are commercially known as "candle nuts," and the kernels are already exported from Fiji and elsewhere. The oil they contain is used for soap-making and other purposes, both in this country and on the Continent.

The sample consisted of four pounds of the seeds, the kernels of which were nearly white, and free from discoloration.

The oil was extracted by means of light petroleum, and the kernels were found to contain 60·8 per cent. of oil, which is equivalent to a yield of 19·8 per cent. from the unshelled seeds. The oil dried on exposure to air in thin films in about ten days.

A number of analyses of candle-nut oil have been made previously, and these show considerable variation in the principal constants recorded. The results obtained at the Imperial Institute by the analysis of oil extracted from the present sample of seeds, and those obtained by investigators who have examined candle-nut oil previously, are given in the following table:—

—	Oil from *Aleurites triloba* examined at the Imperial Institute	Oil from *Aleurites moluccana*, examined by		
		Lewkowitsch	De Negri.	Fendler.
Specific gravity at 15° C.	0·9274	0·92565 (15·5° C.)	0·920	0·9254
Acid value	1·72	-	—	—
Saponification value ...	204·2	192·62	184–187·4	191·8
Iodine value	139·7	163·7	136–139	114·2
Hehner value	96·4	95·5	—	--
Reichert-Meissl value...	1·98	--	--	1·2
Titer test	17·8° C.		20–21° C.	18° C.

These results indicate that the oil belongs to the class of drying oils typified by linseed oil, and would be suitable for the manufacture of soft soap, the preparation of oil-varnishes, paints and linoleum, and for other similar purposes to which oils of this class are applied industrially.

Samples of the nuts were submitted to brokers, who stated that the *kernels* would meet with a ready sale at £12 to £13 per ton (October, 1906.)

MAURITIUS.

A sample of unshelled candle nuts was received from Mauritius in April, 1911. About 18 per cent. of the nuts contained shrivelled or decomposed kernels. Those in good condition were composed approximately of shell 64 per cent. and kernel 36 per cent. The sound kernels yielded 68·1 per cent. of pale, brownish-yellow liquid oil.

The oil had the following constants:—

	Present sample from Mauritius.	Previous sample from Hong Kong.
Specific gravity at $\frac{15\cdot5^\circ\text{ C.}}{15\cdot5^\circ\text{ C.}}$ ...	0·927	0·927
Saponification value	193·7	204·2
Iodine value	151	139·7

A large firm of oil-seed crushers, to whom these candle nuts were submitted, reported that the oil expressed from the kernels would probably be worth about £28 to £30 per ton in Europe. The residual cake is of some small value as a fertiliser, and might be worth from 30s. to £2 per ton (October, 1911). The shells of the nuts are of no commercial value, and for that reason the nuts should be shelled and the kernels alone exported.

PARA RUBBER SEED.

STRAITS SETTLEMENTS AND FEDERATED MALAY STATES.

Specimens of Para rubber seed and of meal prepared from them were forwarded to the Imperial Institute in 1902 from the Straits Settlements and the Federated Malay States, and the results of their examination are given in the following report:

The kernels constituted about 50 per cent. by weight of the whole seeds. On extraction with light petroleum they yielded 42·3 per cent. of oil.

The oil was clear, of light yellow colour, and had an odour somewhat resembling that of linseed oil. It belonged to the class of drying oils, and yielded a clear, transparent film when allowed to dry by exposure to air. The following table gives the constants found for the oil, those of linseed oil being added for comparison:—

	Oil from kernels of Para rubber seed.	Linseed oil.
Specific gravity at 15° C. .. .	0·9302	0·931— 0·937
Free fatty acids—		
Acid value	10·7	—
Calculated as oleic acid, *per cent.*	5·4	—
Ester value	195·4	—
Neutral oil, *per cent.*	94·6	95·5—99·6
Saponification value	191·8	190—195
Iodine value	128·3	170—194

On saponification with caustic soda, the oil yielded a soft soap of yellowish colour.

Para Rubber Seed Meal.—The sample consisted of about 7 lb. of finely ground meal of pale buff colour; it was free from husk, and possessed a pleasant odour.

On extraction with light petroleum, the meal yielded 36·1 per cent. of an oil which had a slightly rancid odour, and, on standing, solidified as a soft, crystalline, yellow mass. It furnished the following constants:—

Specific gravity at 15° C.	...	0·911
Free fatty acids—		
Acid value	...	130·5
Calculated as oleic acid	per cent.	65·6
Neutral oil	per cent.	34·4
Ester value		65·2
Saponification value		195·7
Iodine value		136·2

When heated, the oil began to melt at 19° C., and was a clear liquid at 28° C. It had very marked drying properties, and yielded a solid, transparent film. On saponification with caustic soda, the oil furnished a rather soft soap of a yellowish colour.

In the following table, the constants and properties of the oil extracted from this sample of meal are contrasted with those of the oil obtained from the freshly crushed kernels; the constants of linseed oil are again added for comparison

—	Oil extracted from Para rubber seed meal.	Oil extracted from Para rubber seed kernels (freshly crushed)	Linseed oil.
Yield of oil ... per cent.	36·1	42·3	33-38
Physical state	Solid below 19° C.	Liquid at 15° C.	Liquid at 15° C.
Specific gravity at 15°/15° C.	0·911	0·9302	0·931 0·937
Free fatty acids (calculated as oleic acid) per cent.	65·6	5·4	—
Iodine value	136·2	128·3	170-194

It will be observed that the oil extracted from the meal was solid, whereas that obtained from the freshly ground seed was liquid. The difference is due to the large proportion (65·6 per cent.) of free fatty acids present in the former, whilst the latter contained only 5·4 per cent. of free acids. The cause of this difference in the two oils has been investigated, and it has been found that after the seed has been crushed the oil gradually undergoes decomposition, owing to the action of a hydrolytic enzyme (lipase) contained in the seed.

The meal furnished the following results on analysis:—

	Per cent.
Moisture	9·1
Ash	3·53
Fibre	3·4
Fat	36·1
Proteins	18·2
Carbohydrates	29·67

The ash was found to contain 30·3 per cent. of phosphoric acid (calculated as P_2O_5) present in the form of phosphates, which is equivalent to 1·07 per cent. of phosphoric acid in the meal.

The results of this examination of the Para rubber seed meal indicate that the material thus prepared could neither be used as a feeding stuff, owing to the presence in it of large quantities of free fatty acids, nor for the expression of oil since the latter has been largely decomposed. It is probable, however, that if the oil were expressed from the fresh kernels, the residual cake could be utilised as a feeding material, as is shown by the following comparison between the calculated composition of such a cake and the composition of some commercial feeding cakes:—

—	Moisture.	Ash	Proteins.	Fibre.	Fat.	Carbohydrates.
	Per cent.	Per cent	Per cent.	Per cent.	Per cent	Per cent.
Para rubber seed cake ...	13·36	5·19	26·81	5·00	6·00	43·64
Linseed cake	11·16	5·20	29·50	9·10	9·50	35·51
Cotton-seed cake (decorticated).	9·0	7·10	43·78	5·18	11·38	23·56

These figures show that a cake prepared from Para rubber seed kernels would compare favourably with other cakes as a cattle food, and would contain a particularly low proportion of indigestible matter (fibre).

Commercial Value of the Kernels and Oil. Specimens of both the kernels and oil were submitted to leading brokers. They reported that the oil could probably be used as a substitute for linseed oil and would be worth about 20*l.* per ton, but that oil merchants would not take it up unless they first had an opportunity of testing it in bulk. The brokers considered that it would be more profitable to ship the kernels themselves to this country, as is done in the case of most other oil-seeds. They valued the kernels at 10*l.* to 12*l.* per ton, and added that they would be prepared to take two or three tons at the lower price in order to introduce them into the market (1903).

The Para rubber seed meal was not commercially valued, since in its present condition it could not be utilised in any way. Para rubber seed "cake" of the composition already given should be almost as valuable as linseed cake, which sells at from 5*l.* 15*s.* to 6*l.* 15*s.* per ton (1903).

The results of this investigation lead to the conclusion that the kernel of the Para rubber tree is a valuable economic product, and is likely to become of considerable commercial importance.

The oil possesses properties very similar to those of linseed oil, and should therefore be suitable for the preparation of paints and varnishes, and for the manufacture of rubber substitutes, linoleum and waterproofing materials. It could probably also be used like linseed oil for the manufacture of soft soap. The cake left after expressing the oil from the shelled seeds (kernels) would probably be of value as a cattle food, since its calculated composition compares very favourably with the various cakes at present in use, and it is stated that animals readily eat the kernels in the Straits Settlements.

The results obtained in this investigation of Para rubber seed have since been confirmed by the examination of a number of further samples of the seed which have been forwarded to the Imperial Institute.

PARA RUBBER SEED OIL.

A small consignment of Para rubber seed oil which had been prepared by expression at the Perak Museum was received at the Imperial Institute for examination in 1908. It was stated that the press used was not very efficient, and that the best result obtained was a yield of 34 per cent. of oil from the dried kernels.

The oil was light brown, slightly cloudy, and deposited a brown muddy sediment. After filtration a bright yellow oil was obtained which gave the following results on examination:

	Present sample.	Previous sample
Specific gravity at 15·5/15·5° C.	0·925	0·9302
Acid value	16·8	10·7
Saponification value	192·1	191·8
Iodine value	131·4	128·3

It will be seen that the constants of the expressed oil agree closely with those obtained for the previous sample of oil which was extracted at the Imperial Institute from the kernels by light petroleum.

Samples of the oil were submitted to manufacturers, who confirmed the opinion, previously expressed, that Para rubber seed oil could be utilised as a substitute for linseed oil. The results of technical trials showed that it could be employed in the manufacture of paints or of soft soap. It is, however, inferior in drying power to linseed oil (as would be expected from its lower iodine value), and would consequently command a lower price (1908).

PARA RUBBER SEED CAKE.

A small quantity of Para rubber seed cake, obtained on expressing the oil from the kernels, was received at the Imperial Institute for examination in 1911 in order to determine its suitability for use as a feeding-stuff for cattle.

The cake was fairly soft, and arrived in a very broken condition, much powder being present.

An analysis furnished the following results:—

	Per cent.
Moisture	6·91
Crude proteins	29·93
Consisting of :	
True proteins	27·03
Other nitrogenous substances...	2·90
Fat	17·68
Starch, &c. (by difference)	35·97
Fibre	4·82
Ash	4·69

Nutrient ratio:- 1 : 2·56

(The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.)

Food units: 155

(The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.)

The cake did not contain saponin nor any alkaloid; if any cyanogenetic glucoside were present the amount was less than that necessary to yield 0·01 per cent. of hydrocyanic acid.

It will be seen from the following table that this Para rubber seed cake compares very favourably in composition with the feeding cakes in common use:

—	Para rubber seed cake	Soy bean cake.		Linseed cake		Cotton-seed cake	
		English.	Imported.	Average English	American.	Average decorticated.	Undecorticated English.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	6·91	12·70	17·00	11·16	9·30	9·00	13·75
Crude proteins ...	29·93	38·82	40·50	29·50	33·37	43·78	24·62
Fat	17·68	11·07	9·00	9·50	10·06	11·38	6·56
Carbohydrates (by difference)	35·97	26·51	23·78	35·54	31·84	23·56	29·28
Fibre	1·82	5·85	4·47	9·10	10·37	5·18	21·19
Ash	4·69	5·05	5·25	5·20	5·06	7·10	4·60
Food units... ...	155	151	147	133	140	161	107

The present sample of Para rubber seed cake contains more fat than is desirable, and it would be advantageous to submit the kernels to greater pressure in order to extract more of the oil and thus produce a harder cake.

Feeding Trials.

Feeding trials were conducted for the Imperial Institute with this cake on cows and sheep, and the following report was furnished:—

A quantity of the cake was moistened with water and fed to cows. All, except three which are usually averse to new foods, ate it readily. The dry and powdery condition of the cake suggested the moistening of it before feeding, and it was found that it absorbed its own weight of water, and was then more appetising than when fed dry. Several cows refused it in the dry state, and ate it readily when moist. Three cows received the cake daily for five days, getting 1 lb. each day. They all ate it readily, and no scouring or binding effects were noticeable, nor did the milk or cream appear affected in any way.

The cake was fed in the dry state to sheep and was eaten fairly readily. Some sheep ate their full allowance when it was mixed with other foods, but apparently had less liking for it when fed alone. No exceptional effects were noticed.

A more extended trial with a larger number of animals and a larger daily allowance of the cake would be necessary before the safe limits and effects of this food could be stated.

The results of these trials are satisfactory so far as they go, but, as stated above, it will be necessary to conduct trials extending over a much longer period before a really useful opinion as to the feeding value of Para rubber seed cake can be formed. For results of further trials see *Bull. Imp. Inst.* (1913, **11**, 551).

The Utilisation of Para Rubber Seed.

Since the kernels of Para rubber seed were first investigated at the Imperial Institute in 1902-3, small consignments have been received from time to time in London and sold as oil-seeds, but there has been no large development of this trade, mainly because the demand for seed for planting has been so large as to preclude the collection of seed for industrial use, and, further, the profits from sales of rubber on developed estates have been so large in recent years that little or no attention has been given to the utilisation of by-products. Now, however, when the area of productive Para rubber plantations is increasing rapidly every year, it seems likely that this indifference to the possibility of using these kernels will disappear, and already the expression of oil from the kernels has been undertaken at one or more mills in the East Indies.

It is opportune, therefore, to call attention to several practical difficulties which may occur in dealing with these kernels, and to methods of overcoming them.

Considerable difference of opinion exists as to the cost of collecting Para rubber seeds. The late Mr. Carruthers, in his report as Director of Agriculture for the Federated Malay States in 1908, estimated that 1,000 seeds could be collected there for 4 cents (1·1*d.*), and that 111,400 seeds would be needed to produce 1 ton of kernels. From these data he calculated that the cost of collecting and shelling 1 ton of kernels would be $21·11 ($1 = 2*s.* 4*d.*).

This estimate is considered far too low by Messrs. Macmillan and Petch (*Journ. d'Agric. Trop.*, 1910, **10**, 284, and *Circulars and Agr. Journ., Roy. Bot. Gard., Ceylon*, 1908, **4**, 90), who point out that in Ceylon the cost of collecting 1,000 seeds is 4*d.*, and that Mr. Carruthers' estimate of the number of seeds required to produce 1 ton of kernels is based on the weight of seeds from untapped trees. It has been shown in Ceylon that seeds from tapped trees are smaller and lighter than those from untapped trees, and Messrs. Macmillan and Petch estimate that from tapped trees at least 700,000 seeds would be needed to produce 1 ton of kernels.' Accepting their data, the cost of collecting sufficient seed to produce 1 ton of kernels would be £11 13*s.* 4*d.*, which is certainly a prohibitive price so far as the export of these kernels as an oil-seed is concerned. It should be pointed out that Messrs. Macmillan and Petch's criticism of Mr. Carruthers' estimate is mainly directed to the question of the quantity of seeds required to produce 1 ton of kernels, whereas the principal difference between the two estimates lies in the cost of collection, which appears to be nearly four times as great in Ceylon as in the Federated Malay States. In this connection it may be mentioned that Mr. Ridley, Director of the Botanic Gardens, Singapore, has suggested that the right of seed collection in plantations in the Straits Settlements might be leased to Chinese, who would be able to utilise for this purpose the labour of village children. If this plan is feasible it would appear to afford a comparatively simple solution of the labour difficulty in Malaya.

For shelling the seeds, the installation of machinery is desirable. Trials with Miller's nut-cracking machine at the Imperial Institute have shown that this can be used for the purpose; but it is necessary that trials on a comparatively large scale with the various machines available should be made before definite recommendations in favour of any one make are made. It is essential that the machine adopted should crack the shells without damaging the kernels, since the latter deteriorate somewhat rapidly when they are broken and exposed to air. This is of small importance when the kernels are to be utilised locally and at once for the expression of oil, but it becomes all-important if the kernels are to be exported.

Kernels for export should be thoroughly dried in the sun before being packed in bags for shipment. When these precautions are taken it is quite clear that the kernels can be shipped to Europe, and will arrive in sound condition. In 1909 a small experimental shipment was made to this country from Ceylon, and it behaved quite satisfactorily on expression and furnished oil of excellent quality. In 1911 a further small shipment of kernels was received at Liverpool, and a sample of these, kindly supplied to the Imperial Institute by the purchasers, was found to be in good condition, and to give a normal yield of oil of good quality.

In expressing Para rubber seed oil trouble may arise from the presence of a fat-splitting enzyme in the kernels, as this is taken out with the water expressed along with the oil, and if this aqueous layer is left in contact with the oil, the latter will be hydrolysed into glycerine and fatty acids. A similar fat-splitting enzyme, however, occurs in castor seed, and this occasions no difficulty in the industrial preparation of castor oil, and it may be assumed that with due care no trouble will arise with Para rubber seed kernels from this cause. The kernels should, however, be kept unbroken and should be expressed as soon as possible after shelling, in order to avoid possible deterioration of the oil before expression.

In determining the value of an oil-seed the amount of oil present is the factor of prime importance, but much also depends on the nature of the cake left after expression of the oil. If this contains no deleterious ingredients and is rich in nutritive materials and poor in indigestible fibre, it can be used as a feeding-stuff for cattle, but if deleterious ingredients are present the material can, as a rule, only be employed as a manure. Unfortunately Para rubber seed kernels contain a cyanogenetic glucoside and an enzyme which decomposes this in the presence of water, yielding prussic acid as one product. This, however, is also true of linseed cake, perhaps the most popular feeding-stuff with farmers in this country at the present time, so that the mere production of small quantities of prussic acid affords no ground for suggesting that cake from Para rubber seed kernels will be unsuitable for feeding cattle. It is, however, of the greatest importance to determine as soon as possible what the average maximum yield of prussic acid from cake made from these kernels under industrial conditions is, and if this proves to be no larger than that obtained from linseed cake on the average, it may be assumed that the cake is worth trial as a feeding-stuff. With all new feeding-stuffs it is desirable that extensive preliminary feeding trials should be made before the material is placed on the market, and even should Para rubber seed cake prove to yield less prussic acid than average linseed cake, it will still be indispensable that feeding trials should be made with it. The preliminary trials referred to on page 154 have given promising results but require to be supplemented by experiments on a larger scale.

A detailed examination of Para rubber seed oil has been made in the Scientific and Technical Department of the Imperial Institute, and the results are given in a paper by S. S. Pickles, D.Sc., and W. P. Hayworth, F.I.C., which has been communicated to the Society of Public Analysts (*Analyst*, 1911, **36**, 491). The results show that the oil consists of a mixture of glycerides of linolenic, linoleic, oleic, and stearic acids, with possibly some palmitic acid.

The proportion of unsaturated acids present is lower than in linseed oil, as was to be expected from the slower "drying" character shown by Para rubber seed oil.

CEARA RUBBER SEED

(*Manihot Glaziovii*).

UGANDA.

A sample of Ceara rubber seeds from Uganda was received in March, 1909. The seeds resembled castor seed in outward appearance, but differed from them in having a thick, hard, woody shell and firm nut-like kernels. They were found to consist of 75 per cent. shell and 25 per cent. kernel, and only yielded 12 to 13 per cent. of dark yellow, liquid oil, calculated on the whole seeds. The kernels were extracted from the seeds with difficulty, as on splitting the hard shell the kernel generally broke also. The oil furnished the following figures (column 1 in table) on chemical examination, to which are added for comparison (column 2 in table) the figures for an analysis of the oil by *Fendler* and *Kuhn* (*Ber. deut. Pharm. Ges.*, 1906, **15**, 426) and of Para rubber seed oil, examined at the Imperial Institute:—

—	Ceara rubber seed oil.		Para rubber seed oil.
	(1)	(2)	
Specific gravity at 15/15° C.	0·926	0·926	0·925–0·930
Acid value	0·8	2·18	10·7–16·8
Saponification value	193·0	188·6	191·8–192·1
Iodine value	140·0	137·0	128·3–131·4
Reichert-Meissl value...	—	0·7	—
Unsaponifiable matter	—	0·9	-

The above analyses show that the oil is a drying oil, somewhat similar to Para rubber seed oil. It does not appear likely that Ceara rubber seed would prove a remunerative source of oil, as the seeds are difficult to shell, and the proportion of hard shell is too large to allow of their use in an unshelled condition, for the expression of oil.

"NSA-SANA" SEED KERNELS.

SOUTHERN NIGERIA.

This sample of "Nsa-Sana" kernels, from the Calabar district of Southern Nigeria, was forwarded for examination to the Imperial Institute in June, 1906.

No information was received as to the botanical source of the kernels, but from enquiries subsequently made in Southern Nigeria by the Principal Forestry Officer, it appears that they are the product of *Ricinodendron africanus*, Muell.

The sample consisted of about 3½ lb. of the kernels, which were in fair condition on arrival.

The kernels were found to contain 45·2 per cent. of oil, which dried in a day on exposure to air at the atmospheric temperature, and left a wax-like residue.

The oil has been examined chemically and found to resemble tung oil (Chinese wood oil) in composition (see p. 418). The following table gives the results obtained in the examination of the oil from the nsa-sana kernels and also the constants of tung oil for comparison:—

	Oil from Nsa-Sana kernels	Commercial tung oil.
Specific gravity	0·9320 (at 20° C.)	0·933–0·942 (at 15·5° C.)
Saponification value ..	191·6	190–197
Iodine value . ..	147·7	149–165
Hehner value	95·2	96·3
Titer test ..	35·7° C.	37·1°–37·2° C.

These results, and the behaviour of the oil on drying, seem to show that the oil from nsa-sana kernels could be utilised as a substitute for tung oil; but technical trials would be necessary in order to determine this point. Tung oil is principally sold in the United States of America, but there is also a fair market in this country, where it is used in the manufacture of linoleum and also in lacquer and varnish making. The price of tung oil in London at the date of the report (Feb., 1907) was from £32 to £33 per ton.

The nsa-sana oil could also be utilised for making soft soap, and it would be worth from £18 to £20 per ton for this purpose (Feb., 1907). The value of the kernels would be determined by the amount of oil they contain and the price obtainable for it.

The "cake" left after the extraction of the oil resembled decorticated cotton-seed cake in composition but on examination for poisonous constituents indications of the presence of an alkaloid were observed. On this account and also owing to the nature of the oil which the kernels contain, it seems improbable that the cake could be used as a cattle food, and very careful experiments as to its effects on animals would first have to be made before it could be recommended for this purpose. It could, however, be utilised as a manure, since it is rich in nitrogen.

A sample of unshelled nsa-sana seeds was received from Southern Nigeria subsequently.

It consisted of small rounded nuts, dirty brownish-grey in colour. The shells were very hard and thick, and possessed a bright white internal coating. The kernels, which were white and soft and could not be freed easily from the shells, formed 29 per cent. and the shells 71 per cent., by weight, of the whole seeds. The material received previously consisted of kernels only.

The yield of oil was 47·0 per cent. expressed on the kernels, or 14 per cent. expressed on the entire nuts. It was light yellow in colour, with a pleasant taste resembling ground-nut oil, and dried to a film in a few hours. It gave the following results on examination:—

	Present sample.	Previous sample.
Specific gravity	0·934	0·932
Acid value	1·2	—
Saponification value .	184·7	191·6
Iodine value . ..	148·2	147·7
Hehner value	91·1	95·2
Reichert-Meissl value ...	1·9	--
Unsaponifiable matter ...	1·2	-
Titer test	34·5° C.	35·7° C.

A large sample of the seeds was submitted to a firm of varnish manufacturers, who, after conducting experiments with the oil, reported that in their opinion it would prove a welcome addition to the list of oils useful to the varnish maker. They stated that the oil from the Ricinodendron seeds stands intermediate in properties between tung oil and linseed oil, and would be superior to the latter for many purposes. They further stated that if this oil could be produced cheaply on a commercial scale it would compete with tung oil

Large quantities of these nuts are stated to be available in certain districts of Southern Nigeria, but it seems doubtful whether they could be exported profitably from West Africa for the following reasons:

1. The low proportion of kernel in the nut, and the great difficulty of separating the kernels.
2. The low yield of oil from the entire nuts (14 per cent.).
3. The cake is probably of no value except as a manure.
4. Regarding the oil as equal in value to tung oil (£30 per ton), the market price of the unshelled seeds would not exceed £4 10s. per ton in this country, which, according to the figures given by the Forest Officer at Benin would probably not pay for the cost of collection.

If, however, means could be found of freeing the kernels from the shells in order to reduce the cost of transport, there is little doubt that the kernels would find a ready sale in this country, and that the oil would be at least as valuable as linseed oil, which at the date of the report was worth £21 12s. 6*d*. to £21 17s. 6*d*. per ton.

SEMI-DRYING OILS.

Oils belonging to this class are generally valued in comparison with cotton-seed oil, which commercially is the most important member of the group. The chief oil-seeds yielding oils of this class imported to the United Kingdom are cotton seed, rape seed, and soy beans. In 1910, 690,171 tons of cotton seed, valued at £4,865,863, and in 1911, 596,959 tons, valued at £4,398,675, were imported into the United Kingdom, chiefly from India and Egypt; the following quantities of cotton-seed oil were also imported: 1910, 16,852 tons, valued at £585,656; 1911, 25,466 tons, valued at £811,051. The total exports of cotton seed from India in 1909-10 were 282,491 tons, valued at £1,354,531; and in 1910-11, 299,011 tons, valued at £1,530,173. The total exports of cotton seed from Egypt were 319,229 tons, valued at £2,216,243, in 1910, and 455,879 tons, valued at £3,118,116, in 1911. The United States is the largest cotton seed producing country, but comparatively little seed is exported, most of it being expressed in the country. In the year ending June 30, 1911, 100,679 tons of cotton-seed oil, valued at £3,568,202, were exported from the United States, and only 5,903 tons of cotton seed, valued at £13,738.

The trade in rape seed and rape-seed oil is also considerable In 1909-10, 331,466 tons of rape seed, valued at £3,122,161, were exported from India, and in 1910-11, 329,652 tons, valued at £3,101,296. The imports of rape seed to the United Kingdom in 1910 and 1911 were as follows: 251,324 qrs., valued at £443,530, and 232,199 qrs., valued at £431,376, respectively; the corresponding figures for rape-seed oil in the same years were 13,489 tons, valued at £359,166, and 8,408 tons, valued at £246,193.

The chief point of interest in oils of this class is the enormously rapid increase of the imports of soy beans to the United Kingdom during the last few years. Until the end of 1908 practically no imports of this oil-seed were recorded, whilst in the 1908-9 season 110,000 tons were exported from Vladivostok and Dairen alone, and of this quantity all but 5,000 or 6,000 tons went to the United Kingdom In 1910 the total imports of soy beans into the United Kingdom were 421,531 tons, valued at £3,017,018, but in 1911 the imports fell to 222,657 tons, valued at £1,652,383. For further information see the "Bulletin of the Imperial Institute" (1909, **7**, 308 and 1910, **8**, 40).

Another important oil-seed yielding a semi-drying oil is sesamum seed, of which 149,182 tons, valued at £1,772 767, were exported from India in 1909-10, and 162,327 tons, valued at £2,15[illegible],539, in 1910-11. The greater part of the sesamum seed produced is expressed at Marseilles and does not seem to be imported to the United Kingdom for use as a source of oil, although small quantities are used in the preparation of compound feeding cakes.

COTTON SEED.

NYASALAND.

This sample of Upland cotton seed was received from Nyasaland with a request for information as to whether it could be profitably exported.

The seed contained a considerable quantity of lint, which would render it unsatisfactory for use in an oil mill. If the seed were ginned more carefully in the first instance, or ginned a second time in order to clean it more thoroughly, it would probably be saleable in the United Kingdom at about the same price as East Indian cotton seed, which was worth £6 5*s*. to £6 10*s*. per ton at the date of the report (February, 1910).

COTTON-SEED OIL.

The following report relates to two samples of cotton-seed oil which were examined in connection with an investigation into the possibility of preparing edible fats from Indian cotton-seed oil, to be used in India as substitutes for "ghi" (butter fat).

The first sample was prepared from Indian seed, the second from Egyptian seed: both samples were refined before examination.

	Refined oil from Indian seed.	Refined oil from Egyptian seed.
Specific gravity at $\frac{15{\cdot}5^\circ\text{ C.}}{15{\cdot}5^\circ\text{ C.}}$	0·923	0·923
Acid value . .	0·35	0·21
Saponification value	193	193
Iodine value ...	102	109
Titer test	27·0° C.	28·6° C.
Hehner value	96·2	96·2
Unsaponifiable matter	0·5 (approx.)	1·0 (approx.)
Colour .	Brownish	Yellow
Taste	Not unpleasant; no distinct acrid after-taste.	Not appreciably different from that of the Indian oil.

A little solid flocculent matter separated from both of the oils on standing for several weeks at a temperature of about 19° C.

The above results show that the Indian cotton-seed oil did not differ in composition from the Egyptian cotton-seed oil with which it was compared, and the flavours of the two oils did not differ appreciably. The Indian cotton-seed oil was darker in colour, but it was found possible to reduce the colour to the same shade as that of the Egyptian oil, or to an even lighter shade, by treatment with fuller's earth.

BARBADOS.

A sample of cotton-seed oil was received at the Imperial Institute from Barbados in February, 1906. It was of a yellowish colour, and contained a minute amount of solid matter, which disappeared on heating, and when examined under the microscope was seen to consist of minute crystals. This deposit was too small to examine separately, but it was probably merely "cotton-seed oil stearin."

On chemical examination the oil furnished the following results, to which are added for comparison the usual constants of cotton-seed oil.

	Oil from Barbados.	Usual constants of cotton-seed oil.
Specific gravity at 15° C. ...	0·9226	0·92–0·93
Titer test	31·9°–32·1° C.	32·2°–37·6° C.
Saponification value .. .	196·5	191–196·5
Hehner value . ..	95·07	95·87–96·17
Iodine value	83·5	100·9–116·9
Acid value	0·41	—

It will be seen that the results furnished by this sample of oil from Barbados agree well with the recorded constants of cotton-seed oil except in the iodine value which is much lower than usual. The low iodine value would not interfere with the use of the oil for soap-making, but might arouse suspicions regarding its purity if it were utilised for edible purposes.

SOY BEANS.

HONG KONG.

Four varieties of soy beans were received in July, 1911, as follows:

No. 1.—"White Bean," known locally as "Pak tau." This sample consisted of large, clean, plump, rounded seeds of pale yellowish-brown colour. A few of the seeds were attacked by weevils.

The seeds yielded 18·1 per cent. of oil, which had the usual characteristics of soy bean oil.

The beans were submitted to a firm of oil-seed crushers who valued them at about £8 per ton, net cash, at any English port (February, 1912), and to a firm of brokers, who described them as of similar quality to beans received from Southern Manchuria and also valued them at £8 per ton (February, 1912).

No. 2.—"Green Bean," known by the Chinese as "Tsing tau." These were fairly large, rounded beans, of a pale greyish-green colour externally and yellowish within. Some dirt and a few foreign seeds were present in the sample. They yielded 17·9 per cent. of normal soy bean oil.

The beans were submitted to a firm of oil-seed crushers, who valued them at £8 per ton, net cash, at any English port (February, 1912), and to a firm of brokers, who classed them with beans from Harbin, and valued them at £7 17*s.* 6*d.* per ton (February, 1912).

No. 3.—"Yellow Bean." These beans were somewhat small, round, and yellowish-brown in colour. A good many damaged and shrivelled beans were present in the sample, as well as some dirt. They yielded 16·6 per cent. of normal soy bean oil.

The sample was submitted to a firm of oil-seed crushers, who pointed out that a considerable number of the beans were split, and that a good deal of damage had been done by maggots. The firm valued the beans at about £7 15*s.* per ton, net cash, at any English port (February, 1912), adding that in bulk they would probably arrive in better condition and would then realise the same price as the sample of "white" beans, No. 2. A firm of brokers described them as of fair quality and worth £7 17*s.* 6*d.* per ton (February, 1912).

No. 1.- "Black Bean." This sample consisted of flat beans, with black skin and yellow endosperm. Some impurity was present in the form of foreign seed and dirt. The yield of oil in this case was 15·1 per cent.

The somewhat low percentage of oil yielded by these beans, and the black colour of the seed-coat, make them less valuable than the preceding samples of "white," "green," and "yellow" beans, and they were valued by the firm of oil-seed crushers who examined the previous samples at £7 10*s.* per ton (February, 1912). A firm of brokers valued them at about £7 12*s.* 6*d.* to £7 15*s.* per ton (February, 1912).

A firm of oil-seed crushers to whom the samples of soy beans were submitted stated that the amount of moisture present was in all cases just over 8 per cent., which is considerably less than that in the Manchurian beans commonly imported into Europe. These Hong Kong beans would undoubtedly be preferred from this point of view, and there would also be less risk of damage during transit than in the case of beans containing a higher percentage of moisture.

WEI-HAI-WEI.

Two small samples of soy beans grown at Wei-hai-wei were sent for examination in June, 1909.

No. 1.- Pale green beans marked with brownish patches; contained 17·1 per cent. of oil.

No. 2.—Pale buff-coloured beans smaller than the green variety; contained 17·0 per cent. of oil

These beans do not differ in yield from ordinary commercial shipments of soy beans, the percentage of oil recorded by various observers being from 15·8 per cent. to 18·9 per cent., 18 per cent. being fairly common.

CEYLON.

"Soy beans grown at Jaffna from seed imported from Java."

The sample consisted of small black seeds, mixed with some brown immature seeds and a quantity of tea leaf. It yielded 11·5 per cent. of oil. Yields of from 13·3 to about 22 per cent. have been recorded for soy beans, the usual amount being about 18 per cent.

The oil possessed the normal characteristics of soy bean oil. The current price of soy beans at Hull was £8 13*s.* 9*d.* per ton (August, 1912). The present sample would not realise such a high price, owing to the dark colour of the seeds and their small size, the low yield of oil, and the presence of foreign material.

It would be advisable to cultivate in Ceylon the more valuable ordinary yellow commercial variety of soy bean, in preference to this black, small-seeded kind.

SIERRA LEONE.

The samples of soy beans which are the subject of this report were forwarded to the Imperial Institute in January, 1911. The beans were stated to have been grown at the Station, Headquarters, and Kebe Town farms in the Ronietta district, and it was desired to ascertain their value on the English market.

(1.) "Station Farm, sown in drills."

Brown or blackish pods, containing in most cases two or three beans, but occasionally only one. The beans were of medium size and buff colour; some of them were marked by brownish stains and a number of dark brown and black beans were present. A good many of the beans were rather shrivelled.

(2.) "Station Farm, sown broadcast."

These pods and beans were similar to the preceding sample 1.

(3.) "Headquarters Farm, sown broadcast."

The pods in this sample were rather lighter in colour than those of sample 1, but the beans were similar to those described above.

(4*a*.) "Kebe Town Farm, in drills."

Pods and beans similar to those of sample 1.

(4*b*.) "Kebe Town Farm, broadcast."

The pods in this sample resembled those of sample 1, but the beans were mostly of somewhat better appearance than those of all the foregoing samples, being less shrivelled and of clean buff colour. Some brown and black beans were also present.

The samples were examined with the following results:

—	No 1	No 2	No. 3	No 4a	No 4b
	Per cent	Per cent.	Per cent	Per cent	Per cent
Beans	61	63	63	65	64
Husk	39	37	37	35	36
Proportion of good beans by weight (approx.)	95	97	97	96	97
Moisture in beans ...	10·1	16·0	9·1	10·1	10·5
Oil in beans :—					
As received	20·6	22·3	23·6	21·8	20·8
In beans dried at 100° C.	22·9	24·8	25·9	24·3	23·3

For comparison with these figures it may be stated that soy beans of commerce contain, as a rule, about 18 per cent. of oil in the air-dry beans or about 20 per cent. in the beans dried at 100° C. The present samples therefore contain a very satisfactory percentage of oil, being from 2·6 to 5·6 per cent richer in oil than average soy beans as imported from Manchuria.

The current market price in London of soy beans of good quality is over £7 per ton (March, 1911), and beans similar to the present sample would realise this price, if shipped free from the pods and properly prepared so as to avoid a shrivelled and stained appearence.

SOY BEAN OIL.

HONG KONG.

This was a clear, brownish-yellow oil, which furnished the following results on examination:

Specific gravity at $\frac{15{\cdot}5^\circ\text{ C.}}{15{\cdot}5^\circ\text{ C.}}$	0·924
Acid value	2·5
Saponification value	193·8
Iodine value	130·0

The sample was submitted to a firm of oil merchants, who valued it at £23 5*s*. per ton, in Hull, as a normal soy bean oil. Brokers valued it at 23*s*. 6*d*. per cwt. in London, packed in cases (February, 1912), adding that it represented the finest quality of Hong Kong soy bean oil.

SESAMUM SEED.

SUDAN.

No. 1.—"Sim-sim (sesame) seed, known locally as 'eirawi,' from the Gedaret district of Kassala Province." This sample consisted of white sesamum seed, mixed with 3·5 to 4·0 per cent. of extraneous matter, which could be removed by sifting. The clean seed contained 4·7 per cent. of moisture, and yielded 51·0 per cent. of oil. This yield of oil is normal and satisfactory. The oil had the usual appearance of sesamum seed oil.

The sample, after cleaning, was submitted to brokers, who stated that it was superior to the fair average grade of sesamum seed. They valued it at about £17 per ton delivered at European ports (May, 1912), with large white Bombay seed at £19 per ton, and yellow Chinese at £18 7*s*. 6*d*. per ton.

No. 2.—"'Eirawi' sim-sim seed from the Gedaret district of Kassala Province." This consisted of white seed, mixed with a small quantity of extraneous matter. The clean seed yielded 51·2 per cent. of oil, which is normal and almost identical with the yield from the previous sample from the Gedaret district. The oil possessed the normal characters of sesamum seed oil.

The seed was submitted to brokers, who stated that it was of very good quality and valued it at £17 10*s*. per ton, delivered at European ports (August, 1912), with large white Bombay seed at £17 17*s*. 6*d*. per ton.

ABYSSINIA.

The sample consisted of a mixture of white and brown seeds and was stated by the brokers to be equal to 50 per cent. "white Bombay seed." It was valued at £11 to £11 10*s*. per ton, provided that not more than 3 per cent. of dirt is present (March, 1906).

RHODESIA.

This sample of sesamum seed, known locally as "Lugonea" or "Ndongea" seed, from Southern Rhodesia was sent by the British South Africa Company to the Imperial Institute for examination. The seed is said to be cultivated by the natives, who use it in small quantities for food and also anoint their bodies with the oily pulp obtained on pounding the seed.

The sample consisted of 2 oz. of seed, which varied in colour from pale buff to dark brown; it was clean and free from dirt and foreign seeds.

The sample was submitted for valuation to brokers, who stated that it was equal in quality to Coromandel Bigaree Sesamum seed, January crop, the current value of which at the time of the report was £12 7*s.* 6*d.* per ton c.i.f. delivered in London (January, 1907). They added that large quantities of the seed could be disposed of at this price.

Another sample of 1 oz. of clean white sesamum seed was received from Rhodesia and submitted to brokers for valuation, who stated that consignments of similar character would be worth £14 per ton c.i.f. delivered at Marseilles for November-December shipments (October, 1908).

NORTHERN NIGERIA.

This sample was received at the Imperial Institute in 1909. It weighed 12 oz. and consisted of a mixture of black, brown, and white seeds. The sample was clean and free from admixture of other grain, and yielded 15·2 per cent. of oil, a rather lower proportion than is usually obtained from sesamum seed.

The seed was submitted to brokers, who reported that it represented a fair quality, but that it was somewhat damaged, and as sesamum oil is used for edible purposes, this fact would materially affect the value of the sample. The firm stated that it is easier to sell this product in continental ports than in the United Kingdom, and valued the sample at 40*s.* per 384 lb., less 3½ per cent., delivered ex ship (December, 1909).

It is usual on the Continent to employ the finer qualities of the oil, obtained in the first expression, in the manufacture of edible oils and fats, whilst the oil from the second and third expressions is used for other purposes, chiefly for soap-making. In the United Kingdom, however, the whole of the oil would have to be disposed of for soap-making, and for this reason the seed cannot realise such a high price as it does on the Continent.

SUNFLOWER SEED.

SUDAN.

This sample of sunflower seed was forwarded from the Sudan in January, 1911.

The seeds were small and white, having the usual shape and appearance of sunflower seeds. The sample contained some dust, vegetable debris, and immature seed, which could be removed by sifting. An average sample from the consignment, including the small immature seeds, consisted of husk 54 per cent., and kernel 46 per cent. The kernels yielded 47·9 per cent. of oil, equivalent to about 22 per cent. on the whole seeds. The oil was somewhat viscous and of bright yellow colour, becoming rather cloudy on standing. It had a slight smell and taste.

The constants of the oil, compared with results previously recorded, were as follows: -

	Oil from present sample of seed.	Results recorded for sunflower seed oil.
Specific gravity at 15°/15° C. ...	0·921	0·924 to 0·936
Acid value	4·5	not recorded.
Saponification value	188·3	188 to 194
Iodine value	102·5	119·7 to 135
Titer test	16·6° C.	17° to 18° C.

The constants given above for the oil yielded by this Sudan seed agree with those recorded for sunflower seed oil, except the iodine value, which is lower than the figures usually given. This, however, may be due to the previous results having been determined on commercial samples of the oil which had possibly been "demargarinated." Further, the oil, on account of its iodine value, is usually stated to be a "drying" oil, but on the results now recorded it would be classed as a "semi-drying" oil, and experiments made at the Imperial Institute showed that the oil from the Sudan seed only dried very slowly on exposure to the air in thin films.

The seed was submitted to several firms of commercial experts, including oil-seed crushers and manufacturers of edible fats.

The oil-seed crushers stated that sunflower seed has very seldom been crushed in the United Kingdom, but that it is extensively grown and crushed in Russia, where the seed is decorticated before crushing in order to improve the quality of the oil. The resulting cake finds a large market in Northern Europe as a feeding-stuff, but is very little used in the United Kingdom.

One of the firms reported that the sample of Sudan sunflower seed appeared to be rather old and dry, whilst the seed was light and likely to yield a cake containing a high percentage of woody fibre. They valued it at about £8 per ton delivered in Hull or London (July, 1911), adding that fresh seed of heavier quality would realise a higher price.

Another firm stated that the yield of oil given by this Sudan seed agreed well with previous results recorded for sunflower seed, and that the seed could be classed for crushing purposes with soy beans and cotton seed.

Makers of edible fats reported that the oil obtained from the kernels is fairly sweet and neutral, and would probably be suitable for edible purposes, whilst the residual cake appears to be a good feeding-stuff. The unrefined oil would compete with cheap nut-oils and cotton oil, and the refined product would make a good substitute for olive oil. The firm considered that for these purposes the seed would have to be imported at a low price, and in a decorticated condition, as the shell forms nearly 50 per cent. of the whole seed and would greatly increase the cost of shipment. They stated that they would be interested to receive offers of the decorticated seed.

MAHOGANY SEED OIL.

BARBADOS.

A small sample of mahogany seed oil was received from Barbados in March, 1911.

The oil was clear, dark greenish-yellow in colour, with an odour resembling that of linseed oil and an unpleasant bitter taste.

It was examined with the following results:—

Specific gravity at 15·5°/15·5° C. ...	0·935
Acid value	13·0
Saponification value	193·3
Iodine value	125·0
Titer test	30·5° C.
Hehner value	93·7
Reichert-Meissl value	1·9

The oil dried very slowly on exposure to the air.

The sample of the oil forwarded for examination was too small to enable any technical trials to be made, but specimens were submitted for valuation to soap and varnish manufacturers. The soap-makers reported that this mahogany seed oil resembles soy bean oil, and that it could not be used to replace cotton-seed oil in the manufacture of hard soap. Consequently its value would not be equal to that of cotton-seed oil. The oil could, however, be employed for making soft soap. The varnish-makers considered that the oil could be utilised for mixing with paints, &c., but they pointed out that it dries slowly in comparison with linseed oil, and that, in order to arrive at definite conclusions, a practical trial of some duration would be necessary. It is probable that this oil would realise about the same price as soy bean oil, viz., £26 per ton (July, 1911).

M'FUCUTA SEED KERNELS

MOZAMBIQUE

A small sample of seeds was received from the Mozambique Company labelled "Sementes de Arvore, 'Fucuta,' Colhida em Cheringoma." The seeds were typically euphorbiaceous in shape and structure, and about the size of large castor oil seeds. The kernels were covered with a thin papery skin of a pale grey colour with reddish markings.

The kernels contained 50·97 per cent. of a deep yellow-coloured oil which was practically odourless. It had no marked taste, but after a time produced a persistent irritant effect on the tongue.

Specific gravity at 16°/16° C. .	0·9261
Acid value .	7·76
Saponification value .	188·8
Iodine value .	118·7
Titer test	23·8° C.
Hehner value	95·1
Reichert-Meissl value . .	0·40

The oil dried to a clear film on glass in from 9 to 10 days. The sample of seed was so small that no technical trial of the oil could be made and therefore no definite information as to its value could be given.

In response to a request for further material a larger sample was forwarded in May, 1909. It was labelled "M'fucuta seeds from Cheringoma," and consisted of brown, thin-shelled seeds, about 0·8 inch long and 0·6 to 0·7 inch wide, somewhat resembling castor oil seeds, but larger and having a dull surface. The shells were fairly easily broken, but the kernels were soft and liable to be damaged in the process. Many of the seeds contained no kernels, but good specimens consisted of 60 per cent. kernel and 40 per cent. shell.

The kernels contained 46·4 per cent. of oil, corresponding to 28 per cent. (approx.) in the whole seed, slightly below the amount found in the first sample (see above). The oil was of bright, dark-yellow colour, semi-drying, tasteless at first but producing after a time an unpleasant burning sensation in the mouth. It furnished the following results on chemical examination:—

Specific gravity at 15·5°/15·5° C. ...	0·926
Acid value	2·4
Saponification value	196
Iodine value	122

The oil, generally, resembled that from the kernels examined in 1908 (see above). It was of the semi-drying class and consequently unsuitable for the manufacture of either paints or lubricants, whilst its unpleasant after-taste would render its use as an edible oil impossible.

PURGING NUTS.

LAGOS.

A small consignment of these oil-seeds was forwarded to the Imperial Institute from Lagos in October, 1903.

The seeds were identified at the Imperial Institute as those of *Jatropha Curcas*. This plant is cultivated in the Portuguese colonies for the sake of its seed which is exported to Lisbon and is there employed for the preparation of curcas oil.

The seeds, on chemical examination, gave the following results. The kernels constituted about 66 per cent. by weight of the whole seed. On extracting the decorticated seeds with ether, they yielded 52 per cent. of an oil, which had a yellow colour, a faint, peculiar odour, and a bland, nutty taste.

It furnished the following constants; the results of previous observers are added for comparison:

	Present sample.	Previous observations.
Specific gravity at 15° C.	0·919	0·919 0·925
Free fatty acids -		
Acid value	1·47	—
Free acids (calculated as oleic acid) ... ... per cent.	2·25	0·36 11·8
Saponification value	204·0	192 210
Iodine value	99·1	98 110

This oil can be employed for the manufacture of soap and candles, and also as an illuminant and a lubricant, but is not well adapted for the last-mentioned purpose on account of its semi-drying properties. It is a strong purgative, and in India is used medicinally.

Samples of the seed and the oil were submitted to brokers and experts who reported that the oil can be used for soap-making, but at the present time would not be worth more than £14 to £15 per ton. The cake left after the expression of the oil would be unsuitable as a cattle food owing to its purgative action, and could only be used as a manure, for which purpose it would be worth from £2 to £3 per ton. The value of the seeds, therefore, would not be more than £4 to £5 per ton (May, 1904).

CROTON SEEDS.

NYASALAND.

This sample was forwarded to the Imperial Institute from Zomba in November, 1909. It was labelled "*Croton Tiglium* seeds" and consisted of small, brownish, mottled seeds with the usual characteristic dull surface of croton seeds. The average weight of a single seed was about 0·16 gram. About 8 per cent. of the seeds in the sample had no kernels: the bulk, however, consisted of kernel 64 per cent., and shell 36 per cent.

The kernels yielded 58 per cent. of oil, equivalent to 37 per cent. on the whole seeds.

The oil was of a bright yellow colour, had a faint smell, and possessed the property, characteristic of croton oil, of blistering the skin. It was examined with the following results:—

	Present sample.	Commercial croton oil.
Specific gravity at 15·5/15·5° C.	0·939	0·937 to 0·943
Saponification value	203	194·5 to 215
Iodine value	110	101·7 to 109

These results show that the characters of the oil from the present sample of seeds are identical with those of the ordinary croton oil of commerce.

There is a small but regular demand in the United Kingdom for croton seed, the market price of which was quoted at 40s. to 50s. per cwt. (February, 1910).

CROTON ELLIOTIANUS SEEDS.

EAST AFRICA PROTECTORATE.

A sample of the seeds of *C. Elliotianus*, Baill., was forwarded to the Imperial Institute from Nairobi in January 1906, for examination in order to determine the value of the oil which they contain.

The sample consisted of decorticated seeds, some of which were found to have turned brown. Only the fresh ones were used in examination.

The seeds were extracted by light petroleum, and yielded 27·7 per cent. of a yellowish oil.

On chemical examination the oil was found to possess the following constants, for comparison with which the corresponding figures for croton oil derived from *Croton Tiglium* have been added.

	Oil of *Croton Elliotianus.*	Oil of *Croton Tiglium.*
Specific gravity at 15° C. ...	0·9266	0·937–0·943
Acid value	4·24	—
Saponification value ...	201·5	194·5-215
Iodine value	138·5	101·7-109
Hehner value	94	88·9-89·1
Titer test	13·7°-13·8° C.	—

These constants show that the oil of *C. Elliotianus* is quite different from ordinary croton oil, the product of *C. Tiglium* (see above), and, unlike the latter, it does not appear to possess vesicating properties.

The oil of *C. Elliotianus* would be less suitable for soap-making than cotton-seed oil, as the melting-point of the fatty acids is low, and it might be difficult to sell when large supplies of cotton-seed oil are available. But under present conditions when vegetable oils are scarce and dear this product could be readily disposed of at a price somewhat lower than that of cotton-seed oil.

The oil has been found by Professor Cash of Aberdeen University to possess purgative properties similar to those of castor oil.

CROTON MACROSTACHYS SEEDS

UGANDA.

A small sample of the seeds of *Croton macrostachys*, Hochst., was received from Uganda. These were heavy seeds with greyish-brown or black thick shells and white kernels. The whole seeds were found to contain 19 per cent. of an orange-yellow coloured, rather viscous oil of a semi-drying character having a specific gravity of 0·871 at 99/15·5° C. The amount of oil obtained was not sufficient for further examination. The oil was devoid of any vesicating action on the skin such as is possessed by the oil of *Croton Tiglium*.

OMPHALEA MEGACARPA SEEDS

TRINIDAD.

A small quantity of the seed of *Omphalea megacarpa*, Hemsl. (*O. diandra*), N.O. Euphorbiaceae, forwarded to the Imperial Institute from Trinidad, was examined with the following results:—

The seeds consisted of shell 28 per cent. and kernel 72 per cent. The kernels, when extracted with light petroleum, yielded 65 per cent. of oil, equivalent to 46·8 per cent. in the whole seeds.

The oil was pale yellow, faintly bitter, readily soluble in chloroform or ether, and soluble in 97 per cent. alcohol to the extent of one part in 140 parts at 25° C. It burnt without much smoke or smell, and when exposed to the air in a warm place for several days it only became slightly thicker. The oil was slowly saponified by alkali with the formation of a white soap.

The following constants were determined:—

Specific gravity at $\frac{15{\cdot}5^\circ\text{ C.}}{15{\cdot}5^\circ\text{ C.}}$ ...	0·922
Acid value	1·47
Saponification value	190·3
Ester value	188·8
Iodine value	119·7
Melting point of fatty acids ...	36°–37·5° C.
Solidifying point of fatty acids ...	31·5° C.

The oil is less viscous than castor oil and varies greatly in other respects as is evident from the following comparison. In particular, the iodine value of the Omphalea oil is higher than that of castor oil, and indicates the presence of a larger proportion of unsaturated fatty acids.

	Omphalea megacarpa Oil.	Castor Oil.
Specific gravity $\frac{15{\cdot}5^\circ\text{ C.}}{15{\cdot}5^\circ\text{ C.}}$ ...	0·922	0·959–0·968
Saponification value ...	190·3	176–186·6
Iodine value	119·7	81·4–90·6

Physiological Action.

Professor Cash, F.R.S., has undertaken a study of the physiological action of *Omphalea megacarpa* seeds and has arrived at the following conclusions:—

The seeds exert a purgative action due to the fixed oil, the degree of action being in direct proportion to the amount of oil present.

The oil probably increases peristalsis by stimulating the intramural nervous plexuses of the intestine. It also produces diuresis owing presumably to a stimulation of the kidney tissues, but the exact mode of action is not yet determined.

The dose of the oil is about four grams. The oily nature of the material, apart from the purgative principle, is considered to add slightly to the purgative effect by exerting a feeble mechanical action.

The oil is regarded as a valuable non-irritant cathartic and its activity does not decrease appreciably with age. The dose required is much smaller than that of castor oil and the taste is not unpleasant.

NON-DRYING OILS.

Typical, commercial non-drying oils are those derived from the olive, almond, peach-kernel and ground-nut. Of the typical products of this class included in this part of the Selected Reports the only well-known material is the ground-nut of which a number of samples from various Colonies have been examined. This oil-seed is very little used in the United Kingdom and the best market for it is Marseilles. Full information regarding the cultivation and uses of the ground-nut is given in the *Bulletin of the Imperial Institute* (1910, **8**, 153) Some of the principal producing countries are India, Senegal and Gambia. The exports from India in 1910-11 amounted to 184,507 tons valued at £2,036,394 whilst those from the Gambia in 1910 amounted to 58,156 tons worth £387,943.

Castor oil which is quite different in type from the other oils included in this class is conveniently discussed along with them because it shares with them the characteristic of not drying on exposure to air.

India is the chief country producing castor seed and castor oil. The total exports of castor seed from India in 1910-11 amounted to 2,148,033 cwt. valued at £1,099,975, and of castor oil to 1,099,967 gallons worth £112,697. For information regarding the cultivation and uses of castor seed the *Bulletin of the Imperial Institute* (1911, **9**, 17) should be consulted

GROUND-NUTS.

SUDAN.

A supply of ground-nuts was received at the Imperial Institute from the Sudan in June 1906. It consisted of unshelled nuts, free from dirt, but rather small and somewhat shrivelled.

The percentage of oil in the kernels was 51·9, equivalent to 40·1 per cent. from the unshelled nuts. The yield of oil from the kernels was higher than the average figures recorded, which range from 43 to 45 per cent.

The oil was examined chemically and the results obtained indicated that it was quite equal in quality to the ground-nut oil of commerce.

The nuts were submitted to brokers who reported that they were not of sufficiently good quality to be used for edible purposes but that large consignments could be sold to oil-seed crushers. The current value of the kernels for the latter purpose was stated to be £11 to £12 per ton or £8 to £9 for the nuts (November 1906).

NATAL.

These nuts were forwarded for examination to the Imperial Institute by the Commercial Agent for Natal, in December 1908.

The sample was labelled "Elephant Ground-nuts" and consisted of ground-nut kernels which varied from ½ to ⅞ inch in length and from $\frac{3}{16}$ to ⅜ inch in thickness. The smaller kernels were as a rule much shrivelled. There were also present some blackened perished kernels and a few pieces of straw and husk.

A portion of the sample was submitted to commercial experts, who reported that the nuts were of good quality, but somewhat too dry and with a few damaged kernels. They valued the kernels at £14 per ton delivered in Marseilles (March 1909).

GAMBIA.

Two samples of ground-nuts were received.

No. 1. "Ordinary Gambian ground-nut, Tio, Sika." These were somewhat elongated nuts in good condition, consisting of kernel, 66 per cent., and shell (husk) 34 per cent. Most of the nuts contained two kernels each, and about 13 per cent. contained three. The kernels yielded 50 per cent. and the whole nuts 33 per cent. of pale yellow, liquid oil.

No. 2. "Light-skinned ground-nuts, Bantankilling. From 3 or 4 seeds received from Senegal." The nuts in this sample consisted of kernel, 80 per cent., and shell (husk) 20 per cent. They were rounder than the ordinary variety of ground-nut. Most of them contained two kernels each but none were found with three, and about 16 per cent. had only one kernel. A few somewhat mouldy kernels were present in the sample. The kernels had dirty-white or buff-coloured skins. The kernels contained 49·5 per cent. and the whole nuts 39·6 per cent. of pale yellow liquid oil.

The following table shows the results of chemical examination of oil extracted from these two varieties of ground-nuts:

—	Oil from nuts of sample 1.	Oil from nuts of sample 2.	Commercial ground-nut oil
Specific gravity at 15·5°/15·5° C.	0·928	0·928	0·918–0·925
Saponification value	191	190	185·6–197
Iodine value	89	85	83·3–105

From the results of these examinations it appears that the Bantankilling ground-nuts furnish a larger proportion of kernels than the ordinary Gambia variety and therefore give a somewhat larger percentage of oil calculated on the whole nuts. This difference is, however, probably not sufficient to give the Bantankilling variety any considerable advantage over the ordinary kind from a commercial point of view, unless this variety gives a larger yield of nuts or offers any advantage in cultivation.

A third sample of ground-nuts was forwarded to the Imperial Institute by the Colonial Secretary at Bathurst, Gambia, in January, 1911. It was labelled "Fiji ground-nuts grown at Kotu by Senor Morales." The nuts were large, each containing two kernels. They consisted of kernel 73 per cent. and husk 27 per cent. A sample from Fiji previously examined at the Imperial Institute consisted of kernel 75 per cent. and husk 25 per cent. (see p. 476).

The kernels yielded 48·2 per cent. of oil, whilst those of the sample from Fiji previously examined contained 49·1 per cent. The oil had the usual appearance of ground-nut oil and was not submitted to chemical examination.

The sample was too small for valuation, but ground-nuts of similar quality would, when decorticated, probably realise the normal price of good ground-nut kernels, viz: £14 10s. to £15 10s. per ton in London (March 1911).

There is a small demand for unshelled ground-nuts of this description, but it is very uncertain, and the price shows considerable fluctuations.

CEYLON.

Samples of ground-nuts and ground-nut kernels were received from Ceylon in June 1904. They were of excellent quality. The kernels as extracted from the nuts were valued at £10 to £10 10s. per ton, and the kernels as received from Ceylon were valued at £9 2s. 6d. per ton (July 1904)

FIJI

A sample of "Fiji peanuts, Spanish variety," was received in October 1908.

It consisted of large ground-nuts, some containing two kernels and some only one. The nuts containing two kernels varied in length from 1·2 to 1·8 inch, and those containing one kernel from 0·8 to 1·1 inch. The kernels were from 0·6 to 1·0 inch in length, and formed 75 per cent. of the total weight of the nuts. The kernels yielded 49·1 per cent. of oil. This represents a good average yield.

This sample was too small for trustworthy commercial valuation. The nuts were, however, somewhat larger than usual and might possibly be applicable to special edible purposes.

A second sample received from Fiji in July 1909 consisted of unshelled nuts, was labelled "Spanish peanuts." and was described as representing the 1909 crop grown at the experimental station at Lautoka.

The nuts were mostly in very good condition, but a few were slightly damaged or discoloured. They were large, varying in length from 1¼ to 2 inches with an average of about 1⅜ inch. Most of the nuts contained two kernels but there were a few containing only one. The kernels extracted from the nuts were in good condition, very few being shrivelled or discoloured. They were of normal size, colour and appearance, and formed about 70 per cent. by weight of the unshelled nuts.

The sample of Fiji ground-nuts previously examined at the Imperial Institute (see above) was found to give an average yield of oil, and as the present sample was quite similar no further analysis was made.

The best market for ground-nuts is Marseilles, and for that reason samples of these Fiji nuts, previously shelled, were submitted to a firm in that port for valuation. They reported that the kernels would sell in Marseilles at about the same rate as Coromandel kernels, viz., 30 fr. per 100 kilos. (about £12 per ton) in December 1909.

Samples of the shelled nuts were also supplied to brokers in Liverpool, who stated that they would be worth about as much as Chinese kernels, viz., £13 10s. to £14 per ton, c.i.f. (December 1909).

MONTSERRAT.

Eight samples of undecorticated ground-nuts, grown experimentally in Montserrat, were received for examination in January 1912. The samples were as follows:-

No. 1. "Local."—Rather small nuts, with dirty-looking husks and small kernels with reddish-brown skins. Many of the kernels were shrivelled.

No. 2. "Gambia (3-seeded)."—Fair-sized nuts, which had in most cases clean husks of good colour. The kernels were mostly plump and clean, with pinkish skins; a few however were shrivelled. 22 per cent. of the nuts contained three kernels each.

No. 3. "Gambia."—These nuts resembled the preceding variety, but the kernels were darker, and a larger number were shrivelled: none of them contained more than two kernels.

No. 4. "Spanish."—Small nuts of dirty appearance, with very small rounded kernels which had pale pinkish-brown skins. A good many kernels were shrivelled.

No. 5. "Carolina Running."—Large, rather long nuts, of dirty colour and containing very large kernels, mostly with reddish-brown skins. Some kernels had skins of a dirty brown colour, and a few were shrivelled.

No. 6. "Carolina Running (small seeded)."—Fair-sized nuts of rather dirty colour, with kernels of medium size having skins varying in tint from reddish-brown to dirty brown. A few kernels were shrivelled.

No. 7. "Virginia Running."—Large nuts of good appearance, in most cases having clean-looking husks and somewhat long plump kernels, with rather dark red skins. Some shrivelled kernels were present.

No. 8. "Red Tennessee."—Very long, large nuts, of fairly good appearance, with very dark reddish-brown kernels of fair size; a considerable number of the kernels were shrivelled. Nearly half the nuts contained three kernels. The kernels had a rather unpleasant taste.

The following table shows the average weight of the single nuts in each sample, the percentage of husk and kernel, and the percentages of nuts containing one, two, three, or no kernels:

Sample No.	1	2	3.	4.	5.	6.	7.	8.
Average weight of a single nut in grams.	0·87	1·20	1·14	0·65	1·62	1·36	1·97	1·96
Percentage of husk ...	30	30	33	24	30	26	30	36
Percentage of kernel ...	70	70	67	76	70	74	70	64
Percentage of nuts containing :—								
1 kernel	13	10	16	35	22	17	9	20
2 kernels	83	60	84	61	76	80	91	29
3 kernels	Nil	22	Nil	Nil	Nil	Nil	Nil	49
No kernel ...	4	8	Nil	4	2	3	Nil	2

The nuts were submitted for valuation to (1) a firm of brokers in Liverpool, (2) a large firm of oil-seed crushers in Marseilles, and (3) a firm of merchants in Hamburg. The three firms reported on the samples as follows:—

(1) The samples are all of very inferior colour, and of a quality rarely marketed in Liverpool. They are not fine enough for sale to English fruit merchants or confectioners, and would be more likely to find a market among Continental oil-seed crushers. Their values in Liverpool, ex quay, in bags, would probably be approximately as follows:—

Sample No.	Name.	Price per cwt.	
		s.	d.
1	Local	10	0
2	Gambia (three-seeded)	10	0
3	Gambia	12	6
4	Spanish	9	0
5	Carolina Running	11	0
6	Carolina Running (small seeded)	10	0
7	Virginia Running	12	6
8	Red Tennessee	12	0

(2) These ground-nuts should realise in Marseilles prices similar to those obtained for "Gambia" nuts, the current value of which is 35 fr. per 100 kilos (14s. 2*d*. per cwt.), c.i.f. Marseilles (April, 1912).

(3) The value of the samples for edible purposes, c.i.f. European ports, should be as follows, with Rufisque ground nuts at 36 fr. per 100 kilos. (14s. 7*d*. per cwt.):—

Nos. 1, 2, 3, and 6 about 31 fr. per 100 kilos (12s. 10*d*. per cwt.)

No. 4 about 32 fr. per 100 kilos. (13s. per cwt.)

Nos. 5, 7, and 8 about 30 fr. per 100 kilos. (12s. 2*d*. per cwt.).

It may be pointed out in connection with these valuations that the current price of undecorticated Coromandel ground-nuts in the United Kingdom at the time of the report was 13s. to 14s. per cwt. (May, 1912). Rufisque ground-nuts suitable for edible use are more valuable, and good samples are worth about 17s. per cwt. (April, 1912).

It is clear from the foregoing results that these ground-nuts would be saleable in Europe. The large supplies of undecorticated ground-nuts imported to the Continent are mainly used for the preparation of edible oil, whilst the small quantities imported to the United Kingdom are used as edible nuts. For the latter purpose it is desirable that the husks should be clean and of good colour, and special attention would have to be given to these points if it is proposed to export ground-nuts from the West Indies to the United Kingdom.

GROUND-NUT OIL.

SOUTHERN RHODESIA.

This sample was a pale yellow oil, which on chemical examination furnished the following constants:—

Specific gravity at 15·5° C.	0·916
Acid value	2·0
Saponification value	188·1
Iodine value	93·0

These results show that the product was of good quality.

The commercial experts reported that the oil was decided, pleasant, probably superior to the highest grade oil met with in this country, and worth about £40 per ton (October, 1905).

It is evident from the foregoing report that this sample of ground-nut oil was of good quality and value

NORTH-EASTERN RHODESIA.

This was a sample of very pale yellowish oil with a faint not unpleasant odour and taste. It gave the following results on examination:—

Specific gravity at 15·5°/15·5° C.	0·919
Acid value	2·2
Saponification value	189·7
Iodine value	96·5

This oil would realise the current price of ground-nut oil, £38 to £45 per ton, London (September, 1911).

This sample had the usual characters of ground-nut oil and was of very good quality; and judging from its low acid value and pale colour, it had been carefully prepared.

The value of ground-nut oil varies as indicated by the range of prices quoted, depending on its colour and freedom from unpleasant taste and odour. Fresh oil of as good quality as the present sample would probably realise the higher price mentioned above, if it were obtainable regularly in quantity.

NORTHERN NIGERIA.

This was a small sample of a cloudy, pale brownish-yellow oil, which became bright and lighter in colour on filtering. The oil had a slight unpleasant odour, suggesting that it had been overheated in preparation. The colour and cloudiness of the sample showed that it had not been carefully prepared. Its constants were as follows:—

	Northern Nigeria oil.	Commercial ground-nut oil
Specific gravity	0·916	0·918 to 0·925
Acid value . ..	1·2	—
Saponification value .	187·0	185·6 to 197
Iodine value	83·6	83·3 to 105

The sample possessed the usual characters of ground-nut oil, but on account of its slight peculiar odour and taste it would only be suitable for soap-making.

MAURITIUS.

A sample of this oil was forwarded from Mauritius in April, 1909.

It was labelled "huile de pistache," and consisted of an imperial quart of pale yellow oil having a bland oleaginous odour and taste. On standing it deposited a minute amount of flocculent white matter.

On chemical examination the oil gave figures which were in close agreement with those of the ground-nut oil of commerce.

It was submitted to commercial experts for valuation. They reported that they considered it to be of extra fine quality and that its value was probably about 30*s.* per cwt. (July, 1909.) They added that ground-nut oil would be practically unsaleable in London, but that it would generally be in good demand at Marseilles.

HONG KONG.

Four samples of ground-nut oil were received.

No. 1.—This oil is said to be imported from the Hoitung district of Kwantung Province, and it is stated large quantities are already being exported to San Francisco.

The oil was pale yellow and slightly cloudy.

No. 2.—This oil is said to be produced at Ping-chau, an island within the Hong Kong New Territories.

The sample consisted of pale yellow, clear, bright oil.

No. 3. This oil is said to be imported from Shanghai. It was yellowish in colour, rather darker than sample No. 2, and slightly cloudy.

No. 4.—This oil, which is said to be imported from Chinkiang, was pale brownish-yellow and slightly cloudy.

A small quantity of brown sediment was present in all four samples of oil.

The results of examination and commercial valuation of these oils are shown in the following table:—

—	No. 1	No. 2	No. 3	No. 4.
Specific gravity at $\frac{15\cdot5°\ C.}{15\cdot5°\ C.}$	0·916	0·919	0·919	0·920
Acid value	9·4	3·2	3·3	7·4
Saponification value ...	190·5	190·5	189·5	189·0
Iodine value	87·7	99·4	99·2	100·1
Value per ton in London, with finest ground-nut oil at £38 to £45 per ton (Feb. 1912).	£30 less 2½ per cent discount	£29 less 2½ per cent. discount.		£28 less 2½ per cent discount.

PENTACLETHRA MACROPHYLLA SEEDS.

SOUTHERN NIGERIA.

This consignment of the seeds of *Pentaclethra macrophylla*, commonly known as the "oil bean" or "owala bean" in Southern Nigeria, and as "fai bean" in Sierra Leone, was forwarded to the Imperial Institute by the High Commissioner for the Protectorate, who desired to obtain definite information regarding the value of these beans as a source of oil.

The consignment weighed about 6 cwt., and consisted of large flattened beans covered with a hard brown testa (seed coat). They were from 1·5 to 2·75 inches in length, 1·2 to 1·8 inches in breadth, and 0·3 to 0·4 inch in thickness. The kernels of the fresh beans should be white and soft, but in the present consignment a comparatively small proportion of the kernels were white, the bulk being brown or black, probably as the result of decomposition.

A quantity of the oil present in the kernels was prepared and its principal constants determined. The residue left after extraction of the oil from the kernels was analysed to ascertain its value as a feeding-stuff.

The results of these investigations are as follows:—

	Per cent.
Proportion of hard seed coat in beans (by weight)	20·7
Proportion of kernel in beans (by weight)	79·3
Amount of oil contained in the whole beans	31·2
Amount of oil contained in the kernels (*i.e.*, the beans freed from the seed coats)	39·0

It has been pointed out already that a large proportion of the kernels had become discoloured, and as this had probably affected the oil contained in them, it was considered advisable to prepare two specimens of oil, one from an average sample of the beans, and the other from a selected sample, consisting of beans with undecomposed kernels. The constants of the two specimens of oil so prepared are given in the following table:—

	Oil from beans with undecomposed kernels	Oil from an average sample of beans.
Colour of oil .. .	Pale yellow	Yellowish-brown
Odour of oil	Slightly pungent	Pungent
Specific gravity at 100° C	0·8637	0·8627
Solidifying point	8° C	5° C
Saponification value ...	185	182
Acid value	4·6	10·0
Iodine value	94·3	94·1
Hehner value	94·2	95·7
Unsaponifiable matter...		0·27
Titer test	52·4° C	53·1° C.

It will be seen that the oil from the average sample of beans was darker in colour, more pungent, and possessed a higher acid value (*i.e.* was more rancid) than that prepared from the selected beans. The oil does not "dry" when exposed to the air, even at temperatures slightly above the atmospheric. It possesses an unpleasant pungent odour (even when prepared from undecomposed kernels), which is not removed by any of the simple processes in general use for refining oils. On standing for some time it slowly deposits a quantity of solid fat.

The chemical examination having indicated that this oil might be suitable for the manufacture of soap, a portion of the consignment of beans was submitted to a firm of soap manufacturers, who kindly undertook to extract the oil and make a trial of it as a soap-making material. Considerable difficulty was experienced in preparing the oil for this technical trial; in particular, it was found necessary to decorticate the beans before extracting the oil, in order to avoid inclusion of the brown colouring matter of the hard seed coat.

The firm of soap-makers reported on the oil as follows:—

"The oil obtained from the decorticated seeds was much lighter than that prepared from the undecorticated seeds; it contained comparatively little albuminous matter, but possessed a pungent odour. Its constants were:—

Iodine value	87·07
Acid value	14·3
Titer test	50·15° C.

The oil, despite the high melting point of its fatty acids, yields a rather soft soap. As this soap is inferior in colour, is somewhat softer, and has a far stronger odour than that from cotton-seed oil, we have no hesitation in putting its value at £3 per ton below this oil" (refined cotton-seed oil was at the time of the report worth from £21 to £26 per ton).

Composition of the Meal.—The meal left after the extraction of the oil from the selected beans containing undecomposed kernels was used for analysis. It gave the following results:—

	Per cent
Moisture	12·9
Ash . . .	3·5
Proteins . . .	34·8
Fibre . ..	6·6[*]
Sugar (dextrose)	8·2
Carbohydrates (other than sugar)	33·7

These figures indicate that this meal possesses a high nutritive value, and compares favourably in this respect with the feeding-cakes prepared from linseed, cotton-seed and other similar materials. No analysis of the meal left after the extraction of the oil from the unselected beans was made because this material was very dark coloured and possessed an unpleasant odour, which would prevent its use as a cattle food. Such material could probably only be used as a manure.

It is impossible to say definitely what the commercial value of cake prepared from the beans with undecomposed kernels would be, since the amount of such material obtainable from this consignment was so small that no cake could be prepared, and no feeding trials with animals could be carried out, and such trials are essential before this residue could be safely suggested for feeding purposes.

In drawing conclusions as to the commercial prospects of the oil beans of *Pentaclethra macrophylla* from the results of the chemical examination and technical trial, it should be borne in mind that, as already indicated, the consignment of beans sent to the Imperial Institute was not in a fresh condition, and that the decomposition which had taken place in the kernels of the bulk of the beans had no doubt to some extent adversely affected the oil, and to this circumstance was no doubt due in part the dark colour and objectionable odour referred to by the firm of soap-makers, and it is possible that if the consignment of beans had been fresh a more favourable view of the technical possibilities of the oil might have been taken. That this is the case is shown by the results of trials of a subsequent consignment from Sierra Leone (see below)

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[*] Containing 22·6 per cent. of phosphoric acid (calculated as P_2O_5), and equivalent to 0·55 per cent. of phosphoric acid (calculated as P_2O_5) in the meal.

The results of the chemical examination of the oils derived respectively from undecomposed kernels and from an average sample of kernels (see above) show, however, that the chemical nature of the oil has undergone but little change as the result of the decomposition of the kernels. Consequently the softness of the soap produced is probably a constant feature, and therefore the price obtainable for it, even when made from fresh kernels, will no doubt always be less than that paid for cotton-seed oil, which yields a harder soap

Assuming that it is possible to prepare a feeding-cake from the fresh beans which would to some extent add to their value, beans in good condition would probably be worth from £5 to £5 10s per ton in this country

It appears that small consignments of these beans have from time to time during recent years been placed on the Antwerp market from the Belgian Congo They have met with a slow sale, usually at prices equivalent to about £5 per ton, and it is stated that this price has proved unremunerative to exporters, and that the trade has almost if not entirely ceased.

In conclusion, it appears unlikely that there will be in the near future either a large or profitable market for these beans, and though it might be worth while if the beans are available in large quantities to ship them on the chance of securing a small return, especially when as in recent years oil-seeds are fetching abnormally high prices, it would not be advisable to encourage the natives to plant *Pentaclethra macrophylla* for the sake of exporting the beans.

SIERRA LEONE.

A consignment of the same seeds was received from Sierra Leone in 1909. These were in better condition than the seeds received from Southern Nigeria (see above) and the kernels showed very little discoloration.

As a preliminary examination of these beans had been made already with the small consignment received from Southern Nigeria (see above) it was unnecessary to make a further detailed laboratory examination in this case. The consignment was therefore used almost entirely for a factory trial for the expression of oil. For this purpose it was forwarded to a firm of oil-seed crushers, who pressed over a ton of the beans.

The whole beans contained slightly over 36 per cent. of their weight of oil, and on expression gave the following results:—

First pressing (cold): Yield of oil, 20·2 per cent., calculated on the weight of seeds used.

Second pressing (of cake from first pressing), at 77° C. (170° F.): Yield of oil. 11·17 per cent., calculated on the weight of the cake used.

The total yield of oil by expression was therefore about 30 per cent. by weight of the seeds.

The cold-pressed oil (first pressing) was deep golden-yellow in colour, and on standing deposited a small amount of solid matter. The hot drawn oil (second pressing) was of dull yellow colour, and rather thick consistence. Both oils were free from marked odour, but the hot drawn oil had a faintly bitter after-taste, from which the cold drawn oil was free.

The oil on analysis gave the following results, which are in agreement with those previously recorded for this oil (see above):—

Specific gravity at 15·5° C. (60° F.) ...	0·9194
Saponification value ...	181·2
Free fatty acids, per cent.	0·7

The press-cake gave the following results on analysis:—

	Per cent.
Oil.	12·0
Moisture ..	9·8
Crude proteins	33·2
Carbohydrates	34·8
Fibre	5·7
Ash .	1·5

Both the cold and hot drawn oils would be readily saleable, but as regards the former the firm reported that it could be refined to an almost colourless soap oil, and that it appears to lend itself to the making of a first-class edible oil.

The cake remaining after expression of the oil compares favourably in nutritive value with the meals obtained from cotton-seed and other materials used as sources of feeding-cake for cattle. It was, however, described by the oil-seed crusher as only a low-class feeding article, and probably not worth more than £5 per ton. Before it could be definitely recommended as a cattle food, feeding trials would have to be made.

Regarding the beans as originally received, the oil-seed crushers mentioned that owing to their large size the ordinary machinery for preparing oil-seeds for the expression of oil was unsuitable, and if much of this product were treated, certain adaptations would have to be made. They added, however, that it would be quite possible to dispose of the beans in fair quantities if any large supply were likely to be available, and they estimated the value at £6 per ton delivered in London (August, 1909), if shipped in lots of 50 to 100 tons at a time. It is important that consignments of "fai beans" should be dispatched in good condition, as any considerable proportion of decayed kernels would greatly depreciate their value. It is understood that in spite of the rather low price obtainable for them, small consignments of these beans were being imported into this country (October, 1909), and also to France and Germany, for the manufacture of oil.

"IKPAN" SEEDS.

SOUTHERN NIGERIA.

A sample of "Ikpan" seeds was received at the Imperial Institute from Messrs. Alexander Miller Brother and Co. It was stated that they are very abundant in the Cross River district of Southern Nigeria, where they are cultivated and used for food by the natives.

The seeds could not be definitely identified at Kew but it was stated that they are probably derived from a plant belonging to the natural order Cucurbitaceae. It is possible that they may be the seeds of one of the forms of water-melon (*Citrullus vulgaris*) common in West Africa. The constants of the oil agree with this supposition.

The seeds were extracted with light petroleum and yielded from 40 to 41 per cent. of a pale yellow oil, which in cold weather deposits a small amount of solid matter, which does not again pass into solution at ordinary temperatures. On chemical examination the oil proved to be very similar to cotton-seed oil in composition and properties, as the following constants show:—

Specific gravity at 15° C. ..	0·9181
Acid value	5·5
Saponification value	194·0
Iodine value..	106·0
Hehner value	95·5
Titer test	36·0° C.

Samples of the seeds and oil were forwarded to a commercial firm, who reported that the oil could be used for the same technical purposes as cotton-seed oil, and that its value for soap-making would probably be £1 per ton less than that of cotton-seed oil. It was further stated, however, that the taste of the oil and its behaviour under the influence of heat indicate that it should be specially suitable for edible use, and it was thought that the oil from these "Ikpan" seeds might prove equal for edible purposes to the best ground-nut oil, which varies in value from £30 per ton. In order to form a definite opinion upon this point, at least one ton of the seeds would be necessary to enable the suitability of the oil for edible use to be properly determined.

The cake left after the expression of the oil from the seeds would probably prove to be a valuable cattle food. It is very rich in albuminoids and would, on that account, be suitable for mixing with feeding materials poor in proteins in order to raise the proportion of albuminoids to the required amount. Like all such materials, however, it would require to be tested by feeding trials before being recommended for general use.

In a second sample received from Southern Nigeria the seeds were unshelled, and consisted of 36 per cent. shells or husks and 64 per cent. kernels. The latter yielded 40·6 per cent. of oil, equivalent to 25·4 per cent. on the entire seeds, which is practically identical with the previous result.

The oil was clear and pale yellow in colour, and deposited a small amount of white flocculent matter on standing. It gave the following results on examination:—

Specific gravity at 15° C.	0·922
Acid value	1·4
Saponification value	196·5
Iodine value	107

It seems unlikely that commercial consignments of these seeds could be procured at present in Southern Nigeria for export, since it is stated by the Forest Officer for the Eastern Province that there is a large local demand for them as food at higher prices than they would realise in this country.

SENAT SEED.

SUDAN.

The senat plant occurs as a weed in many parts of the Sudan, and is cultivated on a small scale in Central Gezira, and more generally in the Managil district and the Blue Nile Province Large quantities of the seed might be exported from the Kordofan Province if the cost of transport could be reduced, whilst a considerable quantity would be available also in the Tokar district of the Red Sea Province. Small quantities of the seed were first exported to Marseilles early in 1910, where it sold at about £12 per ton as a substitute for sesamum seed.

The oil expressed from the seed is well known to the natives, who use it for edible purposes. The seeds are also dried and eaten by the people after being crushed, whilst the leaves and fruit cases have been used as a cattle food.

Several forms of the plant are grown in different parts of the Sudan under the following names: "Hameid," "Fagus," "Ajurr," and Tibish." Botanical specimens of the various forms have been received at the Imperial Institute, and were submitted to the Director of the Royal Gardens, Kew, who stated that they all appeared to be cultivated races of *Cucumis Chate*, L. (*C. Melo* var. *agrestis*, Naud.; *C. arenarius*, Schum. et Thonn.) *C. Chate* is said to be indigenous to Egypt, Nubia, and Abyssinia, and Naudin considers it to be the wild type of the cultivated melon.

Six samples of the seed have been examined at the Imperial Institute, with the results given below.

No. 1.—Senat seed. Oval, flat, cream-coloured, cucurbitaceous seeds, 0·7 cm. long and 0·35 cm. wide.

No. 2.—"Fagus" seed. This sample resembled No. 1, but was yellower and somewhat flatter.

No. 3.—Senat seed known locally in Kordofan Province as "Tibish." These seeds resembled in appearance the preceding samples, but they were of a greyish colour and somewhat less rounded in shape. The sample was in a dirty condition.

No. 4.—Senat seed from the Kadugli district of the Jebels Sub-Province, Kordofan. This sample resembled the preceding sample of "Tibish" seed, but was not so dirty.

No. 5.—"Hameid" seed. Light brown seeds, resembling senat seeds in shape and general appearance, but only about one-half as large.

No. 6.—Senat seed from Bara, Kordofan Province. Cream-coloured, flat seeds, rather larger than any of the previous specimens.

All the samples yielded a pale yellow, liquid oil, free from smell or unpleasant taste. The oils from the various samples of seed were examined with the results given in the following table, to which are added the figures for oils from other cucurbitaceous seeds.

—	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Ikpan seed from Southern Nigeria.*	Melon seed (*Cucumis Melo*).	Watermelon seed (*Citrullus vulgaris*).
Yield ... ... per cent.	36·5	31·0	29·5	31·7	30·2	38·4	25·4	13·8	10·8
Specific gravity at $\frac{15·5°C.}{15·5°C.}$	0·923		—	0·923	0·925		0·918 0·922	—	—
Acid value .. .	1·0	—	—	0·7	0·7		1·4–5·5	—	—
Saponification value ..	192·0	190·5	189·3	189·2	187·9	–	191 196·5	193·3	189·7
Iodine value	117·0	121·3	117·0	124·0	128·5	—	106–107	101·5	118
Titer test	30·3° C.	—	—	—	—	–	36° C.	36° C.	32° C.

* See p. 185.

In the case of No. 1, the Hehner value was 96·6; the percentage of unsaponifiable matter, 0·7; and the Reichert-Meissl value, nil.

This senat-seed oil is similar to the oils derived from other seeds of Cucurbitaceæ and on account of its pale colour and freedom from smell and taste would be suitable for edible use.

Utilisation of Senat Husks.

Senat seeds are contained in a melon-like fruit usually about three inches in length. With a view to ascertaining the possibility of utilising the husk of the senat fruit after the removal of the seeds, samples of entire fruits, broken husks, and powdered husks were forwarded from the Sudan.

The powdered husks were examined in order to ascertain their suitability for use as a feeding-stuff. The material was found to have the following percentage composition:—

	Per cent
Moisture	10·63
Crude proteins .	10·75
Consisting of:—	
True proteins	5·43
Other nitrogenous substances	5·32
Fat	2·26
Starch, &c	38·80
Fibre	20·50
Ash	17·06
Nutrient ratio*	1:4·1
Food units†	71·3

No cyanogenetic glucosides or alkaloids were present.

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* *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

† *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The above results show that these senat husks have only a very low feeding value, and contain much fibre and mineral matter. It is, therefore, evident that they would not form a desirable feeding-stuff for cattle, except possibly as a diluent for richer materials.

In view of the high percentage of mineral matter (ash), it was thought they might be of value for manurial purposes. In order to determine this point an analysis was made of the ash, which was found to have the following percentage composition:—

Lime (CaO)	8·42
Magnesia (MgO)	4·11
Potash (K_2O)	42·69
Soda (Na_2O)	0·70
Phosphoric acid (P_2O_5)	2·51
Chlorine (Cl)	2·08
Sulphuric acid (SO_3)	3·85

These figures indicate that the mineral constituents of senat husks should be of value as a manure, particularly for crops requiring potash. It is probable therefore that good results could be obtained by applying the husks direct to the soil as a manure.

BEN SEEDS AND OIL.

These seeds are derived from *Moringa pterygosperma* or *Moringa aptera*, species indigenous to the East Indies, but now widely grown in the Tropics.

NORTHERN NIGERIA.

No. 1. A sample of pods and seeds from the Borgu province was examined. The seed-kernels contained 38 per cent. of oil of pale yellow colour and pleasant taste. The oil was separated into portions respectively liquid and solid at 17° C. (For analysis of oil see table on p. 489).

No. 2 A further supply of about 50 lb. of seed-kernels was received from Northern Nigeria in 1906. These were somewhat mouldy on arrival owing to the fact that they had not been thoroughly dried before packing. To prevent fermentation they were dried by hot air and the greater portion of the sample was sent to a firm of oil manufacturers who obtained 21·14 per cent. of "cold pressed oil," and, on further expression at 60° C., an additional 6·6 per cent. of "hot pressed oil"—a total yield of 27·71 per cent. In both cases ("hot" and "cold" pressed) the oil was of dark colour and contained a high percentage of free fatty acids probably owing to the mouldy state of the seed.

No. 3. This consisted of 107 lb. of seeds. These were expressed hot at a pressure of 45 cwt. per square inch and yielded 14·1 per cent. of yellowish-white oil, which was semi-solid at ordinary temperatures and had a peculiar unpleasant odour. An analysis of the oil is given in the following table.

—	No. 1.		No. 2.		No. 3.
	Extracted oil.*		From decorticated seed		From undecorticated seed
	Liquid.	Solid.	Cold pressed.	Hot pressed.	Hot pressed.
Specific gravity at 15/15° C. ...	0·914	—	0·902	0·898†	0·913
Acid value	15·3	—	49·7	100·5	2·3
Saponification value	189·2	194·4	179·2	178·7	186·0
Iodine value	70·7	68·3	100·3	88·0	67·7
Unsaponifiable matter ...	—	—	1·67	2·69	—

* *Oil separated on standing at 17° C. into liquid and solid portions, which were examined separately.*
† *Specific gravity at* 100/15° C.

Composition of Cake.

The residual cakes left after expression of the oil from the samples 2 and 3 had the following composition. The composition of cotton-seed cake is added for comparison:—

—	Ben seed from Northern Nigeria		Cotton seed cake.*	
	Decorticated No 2	Undecorticated No 3.	Decorticated	Undecorticated
	Per cent.	Per cent	Per cent.	Per cent.
Moisture	5·96	7·5	9·00	13·75
Albuminoids	24·12	30·8	43·78	21·62
Other nitrogenous substances	34·81			
Fat	11·27	11·5	11·38	6·56
Fibre	4·32	21·9	5·18	21·19
Ash	5·66	4·5	7·10	4·60
Other non-nitrogenous substances.	13·86	20·9	23·56	29·28

* *According to Smetham* (*Ann. Jour. Roy. Lanc. Agric. Soc.*, 1909).

The above analyses show that the undecorticated cake is fairly rich in nutritive constituents. Owing to the difficulty of removing the husk or shell from the seed it is probable that only undecorticated-cake would be manufactured if Moringa seed were used commercially as a source of oil.

The cake, however, contains an alkaloid (the quantity is small and its exact nature is not yet known) and also a large quantity of non-albuminoid nitrogenous matter; it is also bitter to the taste, so that it is doubtful whether it could be employed as a feeding-stuff. The only other use to which the cake could be put would be to employ it as a manure, its constituents of value for this purpose being as follows:—

	Per cent.
Lime (CaO)	0·403
Potash (K_2O)	0·803
Phosphoric acid (P_2O_5)	1·089
Nitrogen (N)	4·900

Commercial Valuation.

The oil obtained from sample 3 was examined by a firm of soap manufacturers, who reported that it would be suitable for soap-making and that its value for this purpose would be slightly less than that of cotton-seed oil. They expressed a wish to obtain a few barrels of the oil for trial.

The seed and oil were also submitted to oil-seed crushers, who stated that they might be able to use the seed and expressed a desire to obtain a few tons for practical trial.

Until further trials have been carried out, it is impossible to state definitely the commercial value of Moringa seed. If the residual cake can be used as a feeding-stuff, the value of the seed in the United Kingdom would be about £7 or £8 per ton (May, 1910) according to the price offered for the oil, which would fluctuate in sympathy with that of other soap-making materials. If, however, the cake can only be used as manure, the value of the seed will be less.

It has been frequently stated (see *Bulletin of the Imperial Institute*, 1904, **2**, 117) that Moringa oil is especially suitable as a lubricant for watches and other delicate machinery. A sample of the oil was therefore submitted to a chronometer-maker for practical tests. After trials extending over 18 months, it was found that the oil is not suitable for clocks, as it gets thick and sticky after a time and changes in colour to a dark brown. It corrodes so much that it is believed it could not be used even in very large clocks.

EAST AFRICA PROTECTORATE.

The sample of Ben seeds which is the subject of this report was received at the Imperial Institute in October, 1911.

The sample weighed 10 lb. and consisted of the seeds of *Moringa pterygosperma* (Ben seeds), resembling the seeds of this species from Nigeria previously examined at the Imperial Institute. In about 22 per cent. of the seeds, the kernels were either absent or decayed.

The sound kernels yielded 39·2 per cent. of a yellowish oil, against 35 to 38 per cent. in the case of previous samples. The oil deposited some solid fat on standing and resembled in this respect the oil extracted at the Imperial Institute from Nigerian Ben seeds.

BALANITES ÆGYPTIACA.

Fruits, kernels and oil derived from this plant have been received from Northern Nigeria, the Sudan, and Uganda.

NORTHERN NIGERIA.

Oil.—This was labelled " Betu oil " from seeds of *Balanites aegyptiaca.* It was cloudy, of bright yellow colour, and possessed a somewhat unpleasant smell. A quantity of dirty greenish-brown sediment was present at the bottom of the bottle containing the oil. After filtration the oil was quite clear, but a white flocculent substance was deposited on standing.

Kernels.—These were about ½ inch long, pointed at one end, and about ¼ inch thick: they were light brown, semi-transparent, rather hard, and had a rancid bitter taste. The kernels yielded 58·7 per cent. of oil.

SUDAN.

This sample consisted of the fruits, called in the Sudan " Heglig seeds." They were oval in shape, and had a thin, wax-like outer skin, covering a layer of half-dried, sticky pulp of unpleasant odour; inside this was a hard, thick, fibrous shell, containing the pale yellow, oil-yielding kernel. The yield of oil was 41 per cent. on the weight of kernels, equivalent to 3·6 per cent. on the whole fruit. The oil as extracted from the kernels by solvents was pale yellow and transparent, possessed no marked odour or taste, and showed no tendency to dry after being exposed to the air on a glass plate for several days.

Examination of Oil.

	Balanites oil from Northern Nigeria.	Balanites oil extracted from the Sudan fruits.
Specific gravity ...	0·919	0·9187
Acid value	5·0	1·1
Saponification value	196·7	194·2
Iodine value	92·5	98·2
Hehner value	95·2	98·6
Reichert-Meissl value .	—	trace
Unsaponifiable matter ...	0·6 (approx.)	
Titer test	34·6°C. (approx.)	34°C.
Percentage of oil in kernels ..	58·7	41

The oil is a mixture having roughly the following composition:—olein, 33 per cent.; linolein, 33 per cent.; stearin and palmitin, together 34 per cent.

UGANDA.

A sample of oil was received early in 1907 with the information that it was considered by the natives in certain parts of the Protectorate a specific for sleeping sickness, and that it was used in some parts of the Sudan as a purgative. It was asked that experiments might be conducted with the oil, in order to ascertain whether it had any therapeutic value. Prof. Cushny, F.R.S., kindly undertook to make these trials with (*a*) oil extracted from the kernels at the Imperial Institute, and (*b*) oil as prepared in the Nile Province of Uganda. Prof. Cushny's results show that the oil is of no value in the treatment of sleeping sickness, and that although the native-prepared oil, which was dark-coloured and dirty, exerted an aperient action, this was very slight and not likely to render it of any value in European medicine.

Commercial Value of the Oil and Kernels.

The results of the examination show that the oil of *Balanites aegyptica* closely resembles cotton-seed oil in chemical characters and, like the latter, it could no doubt be utilised in soap-making. Its colour and taste would prevent its use for edible purposes.

Samples of the kernels have been submitted for commercial trial and valuation to a firm of soap-makers, who report that the oil would be worth about as much as refined cotton-seed oil.

It is difficult to give even an approximate valuation for the kernels, since much depends on whether the "cake" left after the expression of the oil is suitable for use as a feeding material.

It is a question for local decision whether it would pay to extract the kernels, which alone are of commercial value, from the fruits for export, as the removal of the pulp and fibrous shell is likely to be a troublesome process.

BALANITES MAUGHAMII FRUITS AND OIL.

PORTUGUESE EAST AFRICA

Statements have been made recently that a species of Balanites has been discovered growing plentifully in the Lebombo Mountains and on the banks of the Umbeluzi River in Portuguese East Africa, which produces large quantities of fruit, containing kernels rich in oil of high quality and suitable for use as an edible oil.

The fruits of *Balanites aegyptiaca* from Uganda, Northern Nigeria and the Sudan have already been examined at the Imperial Institute (see above), and shown to be incapable, under existing conditions, of systematic exploitation for oil, owing to the difficulty, first, of removing the external sugary pulp, and then of extracting the kernel from the thick fibrous shell which occurs under the pulp.

In view of these facts it seemed unlikely that the fruits of this new species from Portuguese East Africa could be of economic value for export, and this opinion has been confirmed by the examination of specimens of the fruit and oil forwarded to the Imperial Institute by H. M. Consul at Lourenço Marques in October, 1911.

The fruit consisted of an outer sugary pulp enclosing a nut with a very hard, tough, fibrous shell; the kernel of the nut was cream-coloured, oily, and about 1 in. long and ½ in. in diameter.

The fruits were identified at Kew as belonging to an undescribed species of Balanites, since named *B. Maughamii*, Sprague. They resembled the fruits of *B. aegyptiaca*, previously examined at the Imperial Institute, but were larger.

The sample was too small to enable the percentage of oil in the kernels to be determined.

The specimen of oil was clear, yellow, and liquid, possessing no marked smell or taste. The constants of the oil are given in the following table, compared with the corresponding figures for the oil of *B. ægyptiaca* previously examined at the Imperial Institute.

—	Present sample.	Oil from kernels of *B. ægyptiaca*	
		From Nigeria.	From the Sudan.
Specific gravity at $\frac{15^{\circ}\text{ C.}}{15^{\circ}\text{ C.}}$	0·916	0·919	0·9187
Saponification value	198·5	196·7	194·2
Iodine value	100	92·5	98·2

This oil of *B. Maughamii* from Portuguese East Africa resembles that of *B. ægyptiaca* in appearance and general character, and if produced on a commercial scale it would probably realise about the current price of refined cotton-seed oil. The difficulty and expense of removing the sugary pulp from the fruit, cracking the shells, and removing the kernels would prevent the exploitation of the product on a large scale.

Since this report was forwarded to His Majesty's Consul at Lourenço Marques, experiments with the fruits have also been made in Germany, and the results confirm those recorded above

CALOPHYLLUM SP. OIL.

INDIA

This sample of oil was received in July, 1906. It was forwarded as the product of *C. tomentosum* but the Officiating Reporter on Economic Products has since stated that it was very probably the oil of *C. Wightianum*.

The oil was of a dark greenish-brown colour, viscid, and possessed a slight unpleasant odour; it contained a quantity of solid matter which dissolved on warming, but separated out on cooling. The oil did not dry when exposed to air in thin layers. It yielded the following results on examination to which are added for comparison those furnished by cotton-seed oil:—

	Oil of *Calophyllum* sp.	Cotton-seed oil.
Specific gravity ...	0·9401 at 17° C.	0·922 to 0·930 at 15° C.
Acid value	27·0	(usually almost free from fatty acids.)
Saponification value	199·2	191 to 196·5
Iodine value ...	79·75	100·9 to 116·9
Titer test	31° C.	28·1° to 39·2° C.

The oil contains a considerable amount of coagulable albuminous material, the presence of which would interfere with its use in soap manufacture. It is very dark coloured, gives a dark soap, and is not bleached satisfactorily by any of the ordinary agents which could be used economically. In view of the high percentage of free fatty acids which it contains it is obviously impossible to use alkali for bleaching it In the condition of the present sample the oil could only be used for soaps of low quality, but, after being hydrolysed and the fatty acids distilled, products are obtained which are suitable for soaps of higher grade.

The defective condition of the oil is possibly due to the use of an unsuitable process for extracting it, perhaps involving the over-heating of the seeds.

The oil would probably be worth about £1 per ton less than cotton-seed oil.

CALOPHYLLUM WIGHTIANUM SEEDS.

INDIA.

This sample was received at the Imperial Institute in May, 1910.

It was labelled "*Calophyllum Wightianum* seed from District Forest Officer, South Canara, Bangalore, Madras, Regd. No. 32123," and consisted of a mixture of fruits and seeds. The fruits were small and ovoid, with brownish, dry, shrunken pericarp. The seeds had brown, brittle husks and yellowish-white, oily kernels. The kernels formed about 60 per cent. by weight of the sample as received, and contained 72·5 per cent. of bright yellow, liquid oil which furnished the following figures on examination:—

—	Oil of *Calophyllum Wightianum*	Oil of *Calophyllum* sp. from India previously examined.	*Calophyllum Inophyllum* oil examined by	
			Fendler.	Lefeuvre.
Specific gravity 15·5 /15·5° C.	0·938	0·940	0·934	0·944
Acid value	13·0	27·0	not recorded.	
Saponification value ...	200·3	199·2	196·0	not recorded
Iodine value	103·0	79·75	92·8	96·0
Titer test	19·6 C.	31° C.	33 C.	33° C.

The amount of unsaponifiable matter in the oil was 1·6 per cent.; Fendler has recorded 0·25 per cent. for the oil of *C. Inophyllum.*

The oil extracted at the Imperial Institute from these seeds of *C. Wightianum* differs somewhat from the oil previously forwarded from India in having a higher iodine value and a lower titer test. It would not be suitable for use as a lubricant, but could be utilised for soap-making. From the results of the chemical examination, the oil of *C. Wightianum* appears to be somewhat similar to the oil of *C. Inophyllum*, which Fendler found to contain palmitin, stearin, and olein. The titer test of the *C. Wightianum* oil is, however, much lower. The oil of *C. Inophyllum* has been stated to possess poisonous properties, and it is therefore doubtful whether the oil of *C. Wightianum* would be suitable for edible purposes.

The seeds of *C. Wightianum* have an unpleasantly bitter taste, and on account of this and the possibility of the presence of poisonous constituents it appears very unlikely that the "cake" obtained on expressing the oil would be suitable for use as a feeding-stuff. The bitter principle seems however to be entirely removed with the oil when the latter is extracted by light petroleum, so that the residual oil-free meal does not possess a bitter taste. The oil can be freed from the bitter principle by shaking it with a solution of sodium carbonate.

As stated in the previous report, the commercial value of this oil would probably be a little below the current market price of cotton-seed oil.

STERCULIA FOETIDA FRUITS.

CEYLON.

These were received from Ceylon in January, 1912 The sample was composed of fruits measuring about 1 inch in length and ½ inch in diameter, consisting of (1) a dark grey, thin papery outer skin (epicarp), enclosing (2) a thin layer of pale brown pulp (mesocarp), surrounding (3) a seed with a very tough, shiny, dark brown shell and a soft, creamy white kernel. The fruits consisted of epicarp 2.5 per cent., mesocarp 16 per cent., shell 33 per cent. and kernel 18.5 per cent.

The kernels yielded 52.1 per cent. of oil, equivalent to 30.8 per cent. expressed on the seeds or 25.3 per cent. expressed on the whole fruits.

The oil was pale brownish-yellow, and had a faint, not unpleasant smell, and no distinctive taste.

	Present sample.	Figures recorded by Bontoux.
Specific gravity at 15.5°/15.5° C.	0.929	–
Saponification value .	192.5	173.1 to 174.3
Iodine value	87.0	81.4 to 83.1

These fruits are stated to be eaten in Ceylon, but it is improbable that they would find a market in Europe as an edible product, since the kernels, which cannot be removed from the shells without considerable difficulty, do not show any superiority over those of numerous other edible nuts which are already imported into Europe in large quantities.

The oil yielded by the kernels is a light coloured, non-drying oil, which might find a market for soap-making or possibly even as an edible oil. It possesses the somewhat unusual property of being suddenly converted into a gelatinous solid when heated to a high temperature, and for this reason is of considerable scientific interest.

CALODENDRON CAPENSE OIL.

EAST AFRICA PROTECTORATE.

A specimen of this oil was received at the Imperial Institute from British East Africa in 1904. The tree yielding the seed occurs rather sparsely in East Africa, and is sometimes grown there and in South Africa as an ornamental plant. It does not occur, so far as is known, in sufficient quantity to be a commercial source of oil, so that it is merely a matter of general interest to record the characters of the oil. The latter is pale yellow in colour with a slight rather pleasant odour and a somewhat bitter taste. It deposits a small amount of solid matter on standing. On examination it gave the following constants:—

Specific gravity	0·9190
Acid value	27·0
Saponification value	192·0
Iodine value	98·4
Unsaponifiable matter	2·1
Titer test	35° C.

These results indicate that the oil is of a non-drying type and would be suitable for soap-making, but, as there is at present no prospect of it being obtained in quantity, its commercial value need not be discussed.

BAOBAB SEEDS (*Adansonia digitata*).

East Africa Protectorate.

These were received in February, 1911. The sample consisted of brown, kidney-shaped seeds, measuring about ½ inch by ⅜ inch, with hard, thick, tough husks, and soft, white kernels.

The entire seeds yielded 11·6 per cent. of oil. The following yields of oil from the seeds of species of Adansonia have been recorded:—

A. digitata (Senegal) ...	12·5
A. Za (Madagascar)	16·4
A. madagascariensis (Madagascar) . .	34·4
A. Grandidieri (Madagascar)	42·6

The oil was viscous, clear, and bright yellow, with no marked taste or odour.

It had the following characters:—

Specific gravity at 15·5°/15·5° C. ...	0·920
Acid value	6·2
Saponification value	193·5
Iodine value	82·0

The results of this investigation show that these East African baobab seeds derived from *Adansonia digitata* contain very much less oil than the baobab seeds exported from Madagascar, which are probably derived from *A. madagascariensis* or *A. Grandidieri*. The small percentage of oil present in the East African seeds would render them of no value in Europe as a source of oil.

Baobab seeds from Madagascar containing about 40 per cent. of oil have been valued at about £7 per ton in Marseilles.

TELFAIRIA PEDATA SEEDS.

From time to time enquiries are received at the Imperial Institute regarding the utilisation of Telfairia seeds, the kernels of which are rich in oil, and are stated to be available in quantity in various parts of East Africa. The following is a summary of the information available on the subject.

The plant *T. pedata* is a perennial climber, belonging to the natural order Cucurbitaceæ. It is indigenous to Eastern Africa, Zanzibar, and Pemba.

The kernels of the seeds are stated to be used by natives in tropical Africa both as a foodstuff and as a source of edible oil, and from time to time the suggestion has been made that the seeds might be exploited commercially in Europe as an oil-seed.

The following analysis of the seeds has been published by Gilbert (see Sadebeck, *Die Kulturgewächse der deutschen Kolonien und ihre Erzeugnisse*, Jena, 1899, p. 245):

	Per cent.
Moisture	6·56
Ash	2·04
Oil	36·02
Protein	19·63
Woody fibre	7·30
Nitrogen-free extractive matter ..	28·45

A sample of the seeds from Zanzibar was recently received for examination at the Imperial Institute. They were flat, irregularly circular in shape, and about 1¼ to 1½ inches in diameter. The single seeds averaged 4·9 grams in weight.

The seeds consisted approximately of fibrous husk 11 per cent., shell 38 per cent., and kernel 51 per cent. A previous investigator has recorded 7, 33, and 60 per cent. of fibrous husk, shell, and kernel respectively. The kernels yielded 56·9 per cent. of viscous, slightly reddish-brown oil. Previous observers have recorded yields of 60 to 64 per cent.

The oil extracted from the kernels was examined with the following results:

	Present sample from Zanzibar.	Figures previously recorded by various observers.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$ ...	0·919	0·915 to 0·9185
Acid value	2·6	0·31 .. 2·44
Saponification value ..	196	186·5 .. 202
Iodine value	89	81·2 ,, 100·7

The fatty acids of the oil are stated to include stearic, palmitic, and telfairic acids, and an unidentified hydroxy-acid of the formula $C_{21}H_{40}O_3$.

The expressed oil belongs to the class of non-drying oils, and possesses a pleasant, slightly sweet taste. It would be suitable for soap manufacture, but the possibility of preparing an edible oil from this source seems to depend on the discovery of a cheap and efficient method of husking the seeds, since the husks contain an intensely bitter substance. The oil-cake remaining after pressing the oil from the kernels could probably be used as a cattle food. The cake left after pressing the unhusked seeds would, however, be unsuitable for this purpose, owing to the bitter constituent present in the husks.

The removal of the husk presents considerable difficulty owing to its tough and fibrous nature, and the process of shelling by hand is long and laborious. A German syndicate of soap- and candle-makers at Mannheim is stated to have investigated the commercial possibilities of these seeds, and to have expressed the opinion that until a machine has been invented for rapidly and cheaply decorticating them it would be inadvisable to place consignments on the European market.

The statement has been made that consignments of these seeds have been sold from time to time in Continental markets, and for that reason enquiries have been made by the Imperial Institute in this country, at Marseilles, and at Hamburg, as to whether these is now any import trade in the seeds. The results of these enquiries show that the seeds do not come on the English market, but they have been offered at Marseilles, although never in commercial quantities. The price asked at Marseilles for the unshelled seeds was 30 francs per 100 kilos. (about £12 per ton), but no business resulted; whilst the husked seeds (kernels) were also offered there some years ago without success. None of the firms with whom the Imperial Institute has been in communication had any knowledge of a machine suitable for the purpose of decorticating the seeds.

It appears that samples of the seeds of *T. pedata*, and also of *T. occidentalis* from West Africa, are received from time to time at Hamburg, but the seeds are not imported there in commercial quantities. No market quotation for the seeds is available at Hamburg, and no machine satisfactory for the decortication of the seeds is known there.

The position with regard to these seeds may be summed up as follows. They are known to yield a fair quantity of oil which could be used commercially. There is a difficulty in making use of them in this way, owing to the fact that the husks contain an intensely bitter substance, which (1) prevents the use of the oil obtained from them for edible purposes, and (2) renders the press cake unsuitable for feeding purposes. This difficulty could be met, as it is in other cases, by shelling the seeds, but unfortunately there is at present no machine available for this purpose, and shelling by hand, even with native labour, appears to be expensive. In spite of these difficulties small consignments of the seeds have been offered from time to time in Europe, but there is no evidence that these have amounted to more than experimental shipments, and it is clear that there is no regular market for the seeds.

In the event of the above-mentioned difficulties being overcome, it should be observed that oil-seed crushers are generally unwilling to take up a new oil-seed unless it is obtainable regularly in large quantities, and so far as can be ascertained at present no large regular supply of Telfairia seeds could be guaranteed even if it were found possible to use them.

CASTILLOA ELASTICA SEEDS.

TRINIDAD.

This sample of the crushed seed of *Castilloa elastica* was forwarded to the Imperial Institute by the Superintendent of the Botanical Department, Trinidad, in July, 1908. It consisted of about 1 lb. of the coarsely ground seed and was of a light brown colour. With it was also supplied a small specimen of the extracted fat which was semi-solid and of yellow colour. Three samples of the fat were submitted to chemical examination. Of these, A was obtained by extracting the seeds with light petroleum for two days in a Soxhlet apparatus, B was obtained by extracting with light petroleum for two hours, whilst C, the specimen referred to above, had been extracted in Trinidad by triturating the crushed seed with carbon disulphide. Since the last-mentioned specimen still retained a small quantity of the solvent, it was heated at 100° in a vacuum before examination in order to remove the last traces of the solvent. On complete extraction with light petroleum the seed yielded 12·5 per cent. of the fat (A) as a pale brown solid which showed a tendency to crystallise owing to the large proportion of free fatty acids present.

The chemical constants of the fat are given in the following table:—

—	A. Extracted with light petroleum	B. Extracted with light petroleum	C Extracted with carbon disulphide
Melting point	Soft at 32° C. and melted completely to a clear liquid at 42°C	—	Semi solid at ordinary temperature. Melted to a clear liquid at 38°C.
Solidifying point	Turbid at 40°C. Solid at 30·5°C.	- -	Turbid at 37°C. Semi-solid at ordinary temperature.
Free fatty acids :—			
1. Acid value	99·8	96·5	28·2
2. Calculated as oleic acid *per cent*	50·2	48·5	14·2
Saponification value	184·4	190·4	196·6
Iodine value	87·9	88·5	90·7
Unsaponifiable matter (resinous substance)	6	—	0·8
Remarks	Seeds completely extracted (2 days).	Seeds only partially extracted (2 hours).	Seeds partially extracted by trituration.

On saponification, the fat yielded a moderately hard soap. The insoluble fatty acids are comparatively hard; when heated they begin to melt at 42·5° C., are completely fused at 47° C. and, on cooling, solidify at 41·5° C. By repeatedly re-crystallising these insoluble fatty acids from alcohol, palmitic acid was isolated and was identified by the following constants. Melting point, 61° C.; acid value, 217·5, iodine value, 0. (The melting point of pure palmitic acid is 62° C., and its acid value 218·7.)

The differences observed in appearance and properties between the specimen of fat C (supplied from Trinidad) and the specimen A are probably due to two causes. In the first place, specimen C was obtained by only partial extraction of the seeds and therefore represents the more liquid portions of the fat, whilst A, having been prepared by complete extraction, contains the whole of the fat, both liquid and solid, together with a certain amount of unsaponifiable, resinous matter. In the second place, whilst both specimens contain a somewhat large proportion of free fatty acids, the quantity in specimen A is much larger than that in specimen C, and it is probable that the presence of these free acids may be due to decomposition of the oil by exposure of the seed in a crushed state to the air for some time before extraction.

A chemical investigation of the fat has shown that it possesses the following approximate composition:

	Per cent.
Oleic acid (free and combined)	46
Palmitic acid (free and combined)...	31
Stearic acid (free and combined)	6
Acids of the linoleic and linolenic series (free and combined)	13

A bitter principle was isolated from the crushed seed by extraction with alcohol, the fat having been previously removed by means of light petroleum. By subsequent treatment of the alcoholic extract, an intensely bitter substance was obtained which crystallises from methyl alcohol in the form of colourless prisms, melts at about 170° C., and is insoluble in light petroleum and in water. This substance contains no nitrogen, and possesses neither acid nor basic properties.

It is doubtful whether the seeds could be commercially utilised with profit, since they furnish only 12·5 per cent. of the oil whilst the crushed seed could not be used as a cattle food on account of its intensely bitter taste.

INOY KERNELS AND OIL.

West Africa.

Small samples of "Inoy" kernels and nuts from West Africa were received at the Imperial Institute from Messrs. Alexander Miller Brother and Co. of Liverpool, in June 1905, and, as the results of the preliminary examination appeared to be promising, a larger quantity of kernels was obtained from the same source for further investigation. The nuts were identified at Kew as the seeds of *Poga oleosa*.

The nuts were dark brown with a thick rough hard shell and contained small ovoid kernels, covered with a brownish-black, thin husk. The kernels were soft and white internally, and very oily.

A few of the kernels were bad and had become brown internally. These were not used in the examination.

The oil was extracted from the kernels by means of light petroleum, and its examination gave the following results

The oil was pale yellow in colour, with a rather unpleasant, oleaginous taste and a peculiar odour. It did not become solid on keeping and solid matter was only deposited after standing for several months.

The kernels contained 60·8 per cent of oil, which had the following constants:—

Specific gravity at 15° C	0·896
Saponification value	184·49
Iodine value	89·75
Hehner value	95·00
Reichert-Meissl value	1·45
Acid value	39·7
Titer test	22° C.

The following table shows the composition of the dry residual meal after extraction of the oil. No determinations of moisture in the meal were made as most of the water was taken out by the dry light petroleum used in extracting the oil from the ground kernels.

	Expressed on dry material. Per cent.
Proteins	41·51
Sugars, reducing	1·32
,, non-reducing (sucrose)	2·50
Other carbohydrates	36·92
Crude fibre	9·00
Ash	8·75

The ash contained 49·1 per cent. of phosphoric acid (expressed as P_2O_5) in the form of phosphates.

The oil resembles, on the whole, cotton seed oil, but has a lower "titer" number.

It could probably be used as a substitute for ground-nut, olive or sesamum oils for edible purposes but, in order to determine the suitability of the oil for edible purposes, it would be necessary to have a consignment of a few hundredweights of the kernels so that the oil could be expressed on a commercial scale, and specially examined from this point of view

The figures given above for the dry, oil-free material, show that the "Inoy" kernels may be expected to yield a nutritious cake suitable for feeding cattle, but further examination is needed to prove its suitability for this purpose. The thin husk on the kernels is not so hard as that on cotton-seed, which is left in the cake, and it is unlikely that there would be any objection to a similar course in the case of the "Inoy" kernels. The thin husk surrounding the kernel should not be confused with the thick hard shell of the "Inoy" nut itself, which would have to be removed previous to export. The difficulty of removing the shells would probably prevent the exportation of the kernels in commercial quantities. At the time of the report the kernels were valued, as an unknown oil-seed, at the nominal price of £9 to £10 per ton in this country (May 1906).

Further samples of "Inoy" kernels, and of the oil prepared by natives in Southern Nigeria, were examined in 1907.

Analyses of the kernels and oil have also been made in this country by Edie and in Germany by Brieger and Krause. The latter authors obtained their material from Kamerun, where the tree is known as "Njore-Njole" (*Tropenpflanzer*, 1908, **12,** 83). It is of interest therefore to bring these various results together, since they serve to show the extent to which the oil content of the kernels and the usual "constants" of the oil vary.

—	*Analyses made at the Imperial Institute*			*Analysis made by Edie.*	*Analysis made by Brieger and Krause.*
	Oil extracted from kernels.		Native prepared oil		
	No. 1.	No. 2.			
Specific gravity at 15°/15°C.	0·896	0·914	0·918	0·9091*	0·9135†
Acid value	39·7	45·3	-	56·0	—
Saponification value ...	184·49	192·9	184·05	188·0	193·05
Iodine value	89·7	90·9	85·35	93·0	93·3
Hehner value	93·0	94·5		—	-
Reichert Meissl value ...	1·15	nil.	—	-	0·66
Titer test...	22°C.	21·5°C.	—	—	
Percentage of oil from kernels	60·8	—	—	57·4	62

* Determined at 20° C. and compared with water at 4° C.
† Temperature not stated.

OIL-SEED FROM SOUTHERN NIGERIA.

Small samples of an unknown oil-seed from Southern Nigeria, and of oil extracted from the seed by natives, were forwarded to the Imperial Institute by a firm of Liverpool merchants with a request for information as to the identity of the seed and of the probable value of the oil and seed. The seeds were forwarded to the Royal Botanic Gardens, Kew, and were there identified as being of the Nat. Ord. Sapindaceae. Further identification was impossible until plants had been propagated from the seeds.

The seeds were about the size of hazel nuts and had a thin reddish-brown soft shell and a lighter-coloured inner skin. The interior was composed of white semi-transparent tissue very rich in oil.

The oil was almost colourless and transparent and had a slightly rancid smell and a bland oleaginous taste; it contained a small quantity of solid "stearin" and yielded the following results upon examination:—

Specific gravity at 15°/15° C.	0·916
Acid value	3·5
Saponification value	186·3
Iodine value	86·7
Hehner value	95·4
Reichert-Meissl value	1·3
Titer test	31·1° C.

As the oil is a non-drying one and free from smell, taste or colour, it would probably be of value as an edible oil, or would yield a good white soap. Attempts are being made to obtain further supplies and information regarding this oil-seed.

TEA-SEED OIL AND TEA-SEED CAKE

HONG KONG.

These materials are obtained from the seeds of *Camellia Sasanqua*, a near relative of the tea-plant, *C. Thea*. *C. Sasanqua* is grown by the Chinese mainly for the sake of its seeds, from which the oil is expressed and used as an illuminant. The cake left after expressing the oil is used as a substitute for soap. The possibility of using it in this way is no doubt due to the large amount of saponin in the cake (see below).

The oil and cake now reported on were received from Hong Kong.

Oil.—This was a yellowish-brown, slightly opalescent oil, said to be imported to Hong Kong from Wuchow on the West River, Kwangsi Province.

On analysis it gave the following results:—

Specific gravity at $\frac{15·5° \text{C.}}{15·5° \text{C.}}$	0·918
Acid value	9·4
Saponification value . .	193·4
Iodine value ..	87·5

The oil was submitted to a firm of soap-makers, who stated that it made a softer soap than cotton-seed oil, and would therefore be worth about £1 per ton less than the latter, the current price of which was £22 2s. 6*d.* per ton in Hull (February 1912).

This oil would find a market in the United Kingdom for lubricating and soap-making purposes. The presence of saponin in the seeds, and sometimes in the oil, would, however, probably render the latter unsuitable for edible use.

Cake.—This material consists of the cake left on expressing the tea-seed oil described above from the seeds of *C. Sasanqua*.

The sample examined was in the form of hard, firm, circular cakes about 1 in. in thickness. It was dark brown, and possessed an unpleasant, pungent, bitter taste.

On examination it gave the following results:—

	Per cent
Moisture ...	8·33
Crude proteins .	6·49
True proteins .	6·13
Other nitrogenous substances .	0·36
Fat .. .	1·31
Starch, etc. . . .	13·21
Fibre	37·13
Ash	3·20

No alkaloids were present, but the material contained 7 to 8 per cent of saponin.

This material cannot be used as a feeding cake, owing to the large amount of saponin it contains.

The cake is also unsuitable for use as a substitute for quillai bark (soap bark), as it contains less saponin than the latter. I appeared, however, to be sufficiently rich in saponin to be of us in the preparation of vermicides for dressing lawns, and sample were accordingly submitted to two firms of manufacturin chemists, in order to ascertain its suitability for this purpose Both firms reported favourably, and offered to purchase tria consignments of the cake.

CASTOR SEED.

UGANDA.

Nine samples of castor seed were received in October, 1910 They were as follows:

No. 1. Bright brown and grey mottled seeds varying in siz from small to medium. A few damaged seeds were present.

No. 2. Medium-sized seeds, of grey colour with very dar brown mottling. A few damaged seeds were present.

No. 3. Large grey and black mottled seeds A few damage seeds were present.

No. 4. Fairly large, elongated greyish-white seeds, lightly mottled with black. A fair number of broken seeds were present

No. 5. Fairly large brownish-grey seeds, mottled with very dark brown. A very few damaged seeds were present

No. 6. Small, greyish seeds, mottled with dark brown or black A few damaged seeds were present.

No. 7. Dark greyish-brown mottled seeds of small to mediun size Hardly any broken seeds were present

No. 8 Fairly large, broad seeds, of coppery-brown colou lightly mottled with dark brown. Some broken seeds wer present.

No. 9. Large, elongated white seeds, mottled with black o dark brown. Some broken seeds were present.

The yields of oil obtained from the samples by extraction wer as follows:—

No. of Sample.	Yield of oil.	No of Sample	Yield of oil.
	Per cent		Per cent.
1	48·0	6	48·9
2	50·8	7	47·6
3	49·4	8	45·
4	47·8	9	48·2
5	50·0		

These seeds would all be readily saleable in Europe. Their commercial value would approximate to that of Bombay castor seed which at the time of the report was worth £12 5s. per ton in th United Kingdom (February 1911).

SUDAN.

The castor plant grows wild in the Sudan, and recently experimental plantations have been made on the Kassala farm with Indian and Java kinds, which have proved superior to the native plant. A variety with brilliant red seed spikes has also been introduced from Borgu in West Africa. It is said to be superior to the indigenous variety and to produce larger seeds. The following table gives the principal results obtained by the examination at the Imperial Institute of castor seed from the Sudan.

Date of Receipt.	Origin.	Description of Seed	Percentage of oil in Seed.	Valuation
November 1905	Berber Prov.	Small to medium, dull greyish brown marbled seeds	46·8	£11 to £12 per ton (April 1906)
,, ,,	Dongola ...	Small, medium and large seeds, varying in colour from reddish brown to dark greyish-brown	47·9	
,, ,,	Upper Nile Prov	Small, greyish brown, marbled seeds	44·2	
,, ,,	Halfa ...	Medium dull greyish brown marbled seeds	47·7	
July 1906 ...	Rumbek, Bahr el-Ghazal Prov.	Small, light brown seeds	44·2	Same as Bombay castor seed
,, ,, ...	Red Sea Prov.	Small, grey seeds	47·0	5s per ton more than Bombay castor seed
,, ,, ...	,,	Small, dark grey seeds.	44·4	Same as Bombay castor seed
,, ,, ...	,,	Small, blackish seeds, not in good condition	48·7	5s per ton more than Bombay castor seed, if shipped in sound condition.
,, ...	,,	Small greyish-brown seeds.	47·0	5s per ton more than Bombay castor seed.
January 1907...	Bahr el-Ghazal Prov	Small, dark brown seeds.	44·0	Same as Bombay castor seed
February 1907	Kassala Prov.	Small, grey seeds...	42·0	Same as Bombay castor seed.
April 1907 ...	Not stated...	Small greyish-brown seed	47·0	About 5s per ton more than Bombay castor seed.
May 1911 ...	Kordofan Prov.	Large, reddish-brown, mottled seeds.	50·0	Same as Bombay castor seed
December 1911	Mongalla Prov.	Small, grey seed ...	43·3	£10 12*s*. 6*d*. per ton (Jan. 1912)

East Africa Protectorate.

Ten samples of castor seed grown in various parts of the East Africa Protectorate were forwarded for examination in December 1908, July 1910, and August 1911.

No. 1. "Embu." Large seeds of mixed colour; some small seeds were also present.

No. 2. "Embu." Small, dark brown, mottled seeds.

No. 3. "Kisuma." Large elongated seeds, mostly brownish, not mottled: other castor seeds of dark-brown colour also present.

No. 4. "Mjakiru." Large, mottled seeds, very dark-brown to black in colour.

No. 5 "Mjbri." Small, mottled, dark-brown seeds.

No. 6. "Nakmene." Small, dark brown, mottled seeds.

No. 7. "Njegegeg." Small, dark brown, mottled seeds.

No. 8. "Karungu." Very small, greyish-brown, mottled seeds.

No. 9. "Grown on the Uasin-Gishu plateau." Large, dark purple-brown seeds, not mottled.

No. 10 "Fort Hall District." Mixed large and small, variously coloured seeds. It contained 49·2 per cent. of oil.

With the exception of No. 10 all the samples were too small for chemical examination, but specimens were submitted to commercial experts, who valued them as follows

Nos. 1, 3, 4 and 6	£9 17s. 6d. per ton	(March 1909)
Nos 5 and 7	£9 10s. 0d. ,,	,,
No. 2	£9 0s. 0d ,,	,,
No 8	£8 10s. 0d. ,,	,,
No. 9	£13 5s. 0d ,,	(October 1910)
No. 10	£12 0s. 0d. ,,	(March 1912)

net weight including bags, delivered free ex ship Hull, less 2½ per cent. discount.

The prices quoted for all the samples were based on the current market value of East Indian castor seed.

These valuations were very satisfactory, the prices quoted for the majority of the samples being in advance of the current value of East Indian castor seed. Very large quantities of castor seed are said to be available in the East Africa Protectorate.

Rhodesia.

Eight samples of castor seed grown near Salisbury, Southern Rhodesia, were forwarded for examination to the Imperial Institute in August 1906.

The following table gives a description of the samples and the yield of oil in each case.—

	Yield of oil. Per cent.
No. 1. Large clean seeds, almost black	47·7
No. 2. Large clean seeds, black and white striped	49·6
No. 3. Large clean seeds, light brown	50·0
No. 4. Smaller seeds, clean, mixed colour	46·8

	Yield of oil Per cent
No. 5. Large clean seeds, light grey or almost white	41·6
No. 6 Large clean seeds, brown, slightly pink	50·0
No. 7. Large clean seeds, chocolate-brown	39·6
No 8. Medium sized, clean seeds, dark brown	46·6

Commercial experts reported that the average value of these samples was about £12 per ton, delivered ex ship in Hull (February 1907).

A further sample of castor seed grown in Rhodesia was received for examination in September 1907 It consisted of large, bright brown seeds with a copper-like lustre and slight white markings The seeds yielded 51·2 per cent of oil of the usual appearance of castor oil but somewhat yellow The results of an examination of the oil were as follows:

Specific gravity at 15·5°/15·5° C.	0·963
Acid value...	1·6
Saponification value	183·0
Iodine value .. .	90·0

The oil was completely soluble in two volumes of 90 per cent alcohol.

The seeds were valued at £11 per ton, with East Indian castor seed a £10 15s per ton (March 1908)

The seeds differed considerably in appearance from the castor seed of commerce, but plants raised from them at Kew have proved to be a form of *Ricinus communis*, the common castor plant The unusual appearance of these seeds would not interfere with their sale

A further sample of castor seed was received from Rhodesia in May 1910. It consisted of clean, dark brown, mottled seed with a few white and black seeds.

The kernels contained 68·7 per cent of oil equivalent to 52·2 per cent. calculated on the whole seeds.

The sample was regarded by experts as of the same value as Bombay castor seed.

Castor oil. A sample of castor oil, prepared locally was forwarded for examination from Rhodesia in 1905 It was labelled " No. 1. castor oil, grown and extracted in Rhodesia," and consisted of nearly colourless, very viscous, slightly turbid oil. On chemical examination it yielded the following results:

Specific gravity at 15·5°/15·5° C. ..	0·959
Acid value	1·2
Acid value (calculated as oleic acid), per cent	0·6
Saponification value	179·6
Iodine value	87·0

One part of the castor oil was found to dissolve in 5 parts of 90 per cent. alcohol to form a clear solution. These results indicated that the product was of good quality, although its value was diminished on account of its turbid condition It rendered clear by filtration, its value in the opinion of commercial experts would be about £26 to £28 per ton (October 1905).

MOZAMBIQUE.

The five samples of castor seed which are the subject of this report were forwarded to the Imperial Institute from Beira in December 1911. They were stated to have been collected in the eastern part of Mossurise, and it was desired to ascertain which of the five varieties gave the largest yield of oil, in order that its cultivation by the natives could be encouraged.

The samples of seed were as follows:

No. 1. Brown mottled, small.
No. 2. Black mottled, medium size.
No. 3. Brown mottled, medium size.
No. 4. Light-coloured, mottled, large.
No. 5. Long, black, large.

It was stated that No. 5 is rare, and that No. 1 is the variety most commonly cultivated.

The samples were all in good condition and were found to give the following yields of oil:

	Per cent.
No. 1	41·9
No. 2	47·0
No. 3	43·5
No. 4	49·6
No. 5	47·1

The samples were all of satisfactory quality, and similar seed would be readily saleable in Europe. The prices realised would depend to some extent on the percentage of oil present, but would approximate to that of Bombay castor seed, the current value of which was £12 7s. 6d. per ton (May 1912). It will be seen that sample No. 4 gave the best yield of oil (49·6 per cent.), whilst Nos. 2 and 5 also gave very good yields (47·0 and 47·1 per cent.). The common variety, No. 1, contained the lowest percentage of oil in the series.

MAURITIUS.

Two samples of castor seed labelled "white variety" and "red variety," respectively, were received from Mauritius in April 1911.

The former consisted of medium-sized, dark brown, mottled, rather dull seed; a few black seeds and a small amount of broken shell were present in the sample.

The "red variety" resembled the "white variety" in colour, but was of brighter appearance and consisted of mixed, small, and medium-sized seeds.

The two samples yielded respectively 45·2 and 45·5 per cent. of oil, approximately equal to the yield obtained from castor seed examined in Mauritius in 1908 (see *Bulletin of the Imperial Institute*, 1909, **7**, 118). The oil possessed the usual characters of castor oil.

These seeds contained about the normal amount of oil, and would realise approximately the same price as Bombay castor seed, viz., £12 per ton in Hull (October 1911).

CEYLON.

In Ceylon the castor plant occurs as a weed in many places and its cultivation is confined mainly to native compounds. Some experiments undertaken at the Royal Botanic Gardens, Peradeniya, have shown that its cultivation in that locality would be unremunerative although it might be made to pay in other parts of the Island. For these experiments seeds were obtained from Calcutta, Madras, Colombo and Hakgala. Samples of the seeds grown were forwarded to the Imperial Institute for examination and valuation, and were reported on as follows:—

No. 1. Madras variety, marked "4 E.S." The sample was of good quality, but had a somewhat large proportion of small seeds. It was about equal in value to that imported from Bombay.

No. 2. Patna variety, marked "6 E.S." These seeds were rather larger than those of the preceding sample. The commercial experts reported that they were of good quality and worth 1s. 3*d*. to 2*s*. 6*d*. per ton more than Bombay seed.

No. 3. Calcutta variety, marked "2 E.S." This sample was of fair quality, but contained a large proportion of seeds which were discoloured and possessed withered kernels. It was valued at from 2*s*. 6*d*. to 5*s*. per ton more than Bombay seed.

No. 4. Major variety, marked "8 E.S." These seeds were of large size, but were considered by experts to be immature, since the kernels were soft and pulpy and did not fill the husks. The ripe seeds would no doubt contain a larger proportion of oil than the present sample, and if in good, sound condition would be worth 7*s*. 6*d*. per ton more than Bombay seed.

FIJI.

Three samples of castor seed grown in Fiji were received at the Imperial Institute for examination in 1909 and were reported on as follows:—

No. 1. "Mexican variety." These were small, dark brown mottled seeds, containing 47·1 per cent. of oil.

No. 2. "Mexican variety." Large white seeds mottled with dark brown, containing 49·6 per cent. of oil.

No. 3. "Hawaiian variety." Medium-sized dark brown mottled seeds, similar to No. 1, but larger, containing 48·5 per cent. of oil.

Castor seed as represented by these samples would probably realise from £9 to £9 10*s*. per ton in London (May 1909).

SOLID OR SEMI-SOLID OILS OR FATS.

This important group includes palm oil, palm-kernel oil and coconut oil as its most typical members, to which may be added Shea butter and the Bassia fats though these are much less important than the first three.

These products are used for the manufacture of soap, candles and lubricants. Coconut and palm-kernel oils are also employed to a considerable extent in the manufacture of cooking fats and similar edible products.

The importance of these various fats as raw materials for industrial purposes may be gathered from the following figures showing the imports into the United Kingdom in 1911: palm oil, 87,114 tons valued at £2,697,997; coconut oil, 56,741 tons valued at £2,260,310.

INVESTIGATIONS IN CONNECTION WITH THE AFRICAN PALM-OIL INDUSTRY

The African oil palm, *Elaeis guineensis*, is the source of a number of economic products. West African natives employ the leaves in constructing huts, the very young leaves (palm cabbage) as a vegetable, and the palm wine extracted from the growing bud of the tree as a beverage. The leaves yield an excellent fibre, but up to the present no economical method of extracting this has been devised (*Bulletin of the Imperial Institute*, 1903, **1**, 23, and 1907, **5**, 118). In international commerce the only oil-palm products of importance are palm oil and palm kernels, both of which are extracted from the fruits of the tree. The great importance of the palm-oil industry may be gauged from the figures given above for imports of crude palm oil to the United Kingdom. In spite of the magnitude of this industry it has long been recognised that the extraction of the oil, which until quite recently was carried on entirely by natives in West Africa, is managed in a very primitive and wasteful fashion. From time to time attention has been directed by investigators to the necessity of remedying this state of things, and in particular a considerable amount of attention has been devoted to the possibility of introducing machinery for the extraction of the oil and a considerable number of machines have been devised some of which are now in use in West Africa.

In this country some attention has been given during recent years to this subject as the result of enquiries emanating from importers of palm oil and palm kernels in Liverpool, and on the initiative of the Director of the Imperial Institute, systematic investigations were made in the British West African Colonies by the Inspector of Agriculture in West Africa and by Officers attached to the local Forestry and Agricultural Departments. These enquiries have been directed mainly to the following points: (1) the extent to which the areas occupied by the oil palm in West Africa are at present being worked for palm oil and palm kernels, (2) the relative values, as sources of these two products, of the several varieties of oil palm now known to exist, (3) the distribution of these varieties in the different Colonies and Protectorates of British West Africa, and (4) the extent to which machinery is now being used in West Africa for the extraction of palm oil and kernels. As a result of these investigations a great deal of new information was obtained and a large number of samples of palm fruits, nuts, kernels and oil were sent to the Imperial Institute for examination, mainly with a view to determining whether the fruits of any one variety of oil palm exhibited such advantages in yield of oil or in ease of extraction as to warrant the planting of that variety in preference to others.

The data thus obtained have been utilised in the preparation of this article.

DISTRIBUTION OF THE OIL PALM.

The oil palm is indigenous to West Africa, and occurs in the coast belt almost continuously from the French colony of Senegal to the Portuguese colony of Angola, or approximately from 16° N. lat. to 10° S. lat., but is found in greatest abundance from Sierra Leone to Kamerun. Inland it penetrates to great distances and is found as far in the interior as the great lakes and occurs less frequently right across the continent and in the islands of Zanzibar and Pemba. Dense forests of oil palms are, however, only found in the coastal region, and in West Africa it does not occur thickly much beyond 200 miles from the coast. The commercial supplies of palm oil are obtained mainly from Southern Nigeria, Sierra Leone, the Gold Coast Colony, Dahomey, the French Congo, Kamerun, Togoland and Angola, whilst there have been in recent years small exports of palm kernels from the island of Pemba on the east coast and of palm oil from German East Africa, where oil palms occur in abundance along the shores of Lake Tanganyika, but owing to lack of transport facilities are not much worked for export.

In addition to these African sources the oil palm also occurs in Brazil, Guiana, the West Indies and Mexico. It has been introduced in the Federated Malay States, Borneo, Java, the Philippine Islands and other islands of the Pacific, and from time to time small quantities of oil and kernels have been exported from several of these countries, but at the present time none of them contributes important amounts to the commercial supply of these products.

Enquiries received recently at the Imperial Institute indicate that the question of cultivating the oil palm is being considered by planters, particularly in the Federated Malay States and in certain of the Pacific Islands. In forming such plantations it should be remembered that there are enormous areas covered by the oil palm in West Africa, the greater part of which, according to competent authorities, are as yet almost unworked. It is possible, however, that such plantations in suitable localities having a plentiful supply of cheap and intelligent labour, capable of using machinery for the extraction of oil and kernels, might be remunerative, but at present no definite data are available on this subject.

DESCRIPTION OF THE TREE.

The full-grown oil palm may attain a height of about sixty feet, and consists of a stem covered throughout its length with the bases of dead leaves, and bearing at the apex a crown of large, pinnate leaves, each of which may be fifteen feet in length with leaflets two or three feet long. The tree is very slow growing, and from measurements made in the Agege district of Southern Nigeria reaches a height of six to nine inches in three years, twelve to eighteen inches in four or five years, eight feet in ten years, and thirteen to fourteen feet in fifteen years, and it is estimated that it attains its full height of sixty feet in about one hundred and twenty years. The fruits are borne in large bunches termed "heads" or "hands," which are small and numerous when the tree first begins to bear (this varies from the fourth to the eighth year according to climatic conditions, etc.), but decrease in number and increase in size in the next few years; thus in Southern Nigeria, according to Thompson, as many as thirty "heads" may be formed at first, decreasing to anything between two and twelve as the tree ages. The fruits are usually from one to one and a half inches in length, and three-quarters to one inch in diameter and are roughly egg-shaped, the narrower end being the apex. The colour and size depend on the variety of oil palm, but usually the fruits are reddish-brown or orange in tint. The fruit is botanically a drupe and consists of three well-marked portions. Outside is a layer varying in thickness and composed of a soft fibrous pulp (pericarp), carrying from fifty-five to sixty-five per cent. (see tables of analyses, pp. 517, 525) of an orange-coloured semi-solid fat, which when extracted constitutes the palm oil of commerce. Inside this pulp is the palm nut (endocarp), consisting of a hard woody shell, which may vary considerably in thickness, enclosing usually a single palm kernel, though sometimes two or even three are present; the kernel is the second useful product of the palm fruit, it is dark reddish-brown or almost black externally, and internally consists of a rather hard, white "flesh" loaded with oil, which when extracted constitutes the "palm-kernel oil" of commerce.

The tree will apparently grow on most soils which are capable of holding a fair quantity of moisture, but it is only on rich moist soils and in districts having a fairly high rainfall (50 to 70 inches on the average) that it gives good yields of fruit. Thus, in an article on the oil palm in Southern Nigeria (*Southern Nigeria Gazette*, 1908, No. 10, Suppl.), it is pointed out that the common variety is confined to the moist belts of country, and is most plentiful on the native farms and in the evergreen forests of the Niger Delta and some of the littoral districts of the Eastern province, where a heavy annual rainfall is experienced. In the hinterland of Southern Nigeria, where the rainfall is deficient the distribution of the tree follows the evergreen belts of the forest skirting the large streams. It is conspicuously absent from the impoverished grass-covered soils on which the fan palm typically occurs, indicating that a dry climate and poor soil do not suit it.

CULTIVATION OF THE OIL PALM.

In most parts of West Africa the tree is not regularly cultivated, the natives depending entirely on wild untended forests for their supplies of palm fruits, but in some districts, for example, in the Krobo district of the Gold Coast and in the Camayenne district of French Guinea, a good deal of care is expended by the natives on the groves of palm trees. As a rule, however, all that is done is to collect seedlings from the forest and to plant these on newly-farmed lands or in areas in which the trees have been destroyed by fire or in other ways. Generally these seedlings are not even spaced out at regular intervals, and the only care taken of them consists in cutting away the undergrowth so that it may not interfere with the development of the young plants. For transplanting in this way seedlings from two to three feet high should be selected, and the planting out should be done in the rainy season. M. Adam recommends that a space of from twenty to twenty-six feet should be left between each plant and the next, or more than this where a catch crop of maize or cassava is to be taken off the land as well. In Southern Nigeria it is often found that in areas cleared for farming large numbers of palms subsequently spring up in the course of a year or two, and these are often thinned out or transplanted all over the farm. In some districts of the Western province of Southern Nigeria a few of the leaves are removed each year from the crowns of the trees, by which means the yield of fruit is said to be increased by from twenty-five to fifty per cent. The native practice of tapping the tree for palm wine often leads to its destruction, and in French Guinea and Dahomey decrees have been issued forbidding this practice and also the cutting down of palm trees.

The oil palm is attacked by a considerable number of insect and fungoid pests. The leaves are frequently covered by lichens and are also attacked by a species of "tar," but the tree does not seem to suffer as the result of these growths. A borer, *Rhyncophorus phoenicis*, akin to the "coconut palm borer," attacks the young shoots by boring into them to lay its eggs, and this, together with the damage caused by the larvae feeding on the young leaves and succulent tissues, frequently causes the death of the tree. In Dahomey the trees are attacked by a species of *Oryctes* and also by *Aspidiotus destructor*, but these do not appear to cause much damage.

Bush fires are also destructive to the palm trees, especially to the young seedlings.

VARIETIES OF OIL PALM.

In 1851 Welwitsch described two varieties of oil palm, which he named *Elaeis microsperma* and *Elaeis macrosperma*, and since that date practically nothing was done in the way of differentiating the oil palms of West Africa until 1902, when Preuss published the results of his investigations of the varieties occurring in Kamerun (*Der Tropenpflanzer*, 1902, **6**, 515), although the occurrence of three varieties in the Gold Coast was noted in 1889 in a report on "Economic Agriculture on the Gold Coast"

(*Papers relating to her Majesty's Colonial Possessions* No. 110, Gold Coast [C. 5987-40]). Since then numerous investigations on this subject have been made in the British, French and German West African possessions.

From an economic standpoint perhaps the most important fact established is the existence in all these countries of a variety yielding fruits containing thin- or soft-shelled nuts (endocarp), with a thick layer of oily pulp (pericarp). The importance of this arises from the fact that throughout West Africa the palm nuts are almost invariably cracked singly by hand, and since hundreds of thousands of tons of palm kernels are exported every year the expenditure of labour in cracking these nuts would be materially reduced if thin- or soft-shelled nuts were available in large quantities in place of the common thick-shelled variety.

In the following paragraphs an account of the palm-oil industry in some of the more important producing areas in British West Africa is given, together with such information as is available regarding the varieties known, and their relative economic values as sources of palm oil and kernels.

For more detailed information on this and other points connected with the industry throughout West Africa (British and Foreign) the following articles and notes in the *Bulletin of the Imperial Institute* should be consulted: --

Investigations in connection with the African Palm-oil Industry, Vol. VII. (1909), p. 357.

The African Palm-oil Industry, II., Vol. XI (1913), p. 206

A new Palm-nut cracking Machine, Vol VIII. (1910), p. 58

Utilisation of Palm Oil as an Edible Fat, Vol. IX. (1911), p. 60.

Ordinances relating to the Oil Palm Industry of Southern Nigeria, Vol. IX. (1911), p. 297.

Experimental cultivation of "Lisombé" Oil Palm in Kamerun, Vol. IX. (1911), p. 157.

Composition of Palm Fruits from Dahomey, Vol. IX (1911), p. 158.

Extraction of Palm Oil and Kernels by Machinery, Vol. IX. (1911), p. 403: Vol X (1912), p 192: Vol. XI. (1913), p. 155

Exploitation of Palm Oil and Palm Kernels in the Belgian Congo, Vol. IX. (1911), p. 403.

Progress of the Palm Oil Industry in the Gold Coast, Vol. X. (1912), p. 316.

Cracking and Drying of Palm Nuts in Southern Nigeria, Vol X. (1912), pp. 492, 668.

GAMBIA.

Little attention has been paid so far to the production of palm oil and palm kernels in this Colony, and the oil does not even seem to be extracted locally to any considerable extent by the natives for use as a cooking fat. Only one variety of the oil palm is known to exist, and that is most abundant in the Kommbo and Fogni provinces. The export of palm oil in 1911 amounted to 650 gallons valued at £46. Only small exports of palm kernels have been recorded in recent years, as the following table shows:—

Palm Kernels.

1908.	1909.	1910.	1911
Tons.	Tons.	Tons	Tons.
391	389	467	411
£	£	£	£
3,488	3,526	5,640	4,758

SIERRA LEONE.

The oil palm is very abundant in this Colony and the hinterland, so much so that in many parts, particularly in the Sherbro and Panguma districts, the population is insufficient to work the palms fully. Only one variety of palm occurs, and that is of the ordinary type having thick-shelled nuts. As is generally the case, the fruits even on the same tree show considerable variation, but the Inspector of Agriculture for West Africa, who has made careful investigations on this point, states that although different names are given by the natives to the fruit at different stages of growth, he was unable to find any evidence of the existence of more than one variety of palm, and this yielded a fruit having a thick-shelled nut and a thin pulp. The industry has shown considerable expansion since transport facilities were improved by the opening of the railway at the end of 1905. The exports of palm oil and kernels from the Colony in recent years are shown in the following table: —

	1908.		1909.		1910.		1911	
	Galls.	£	Galls	£	Galls	£	Galls.	£
Palm oil ...	489,637	36,451	851,998	64,273	645,339	62,852	725,648	69,927
	Tons.	£	Tons.	£	Tons	£	Tons.	£
Palm kernels	33,721	332,887	42,897	482,611	43,031	644,684	42,892	557,318

GOLD COAST COLONY

According to a report by Mr. A. E. Evans, Travelling Instructor in Agriculture in the Gold Coast, the oil palm is widely distributed in that Colony, but is most abundant in the Eastern and Central Provinces. A number of varieties of oil palm, falling into three main groups, have been recorded by the Agricultural Department. The following brief description of these may be given: —

Group 1.—Fruits large; colour of pericarps varies from yellowish-white to blackish-red; nuts hard.	"Abe-pa" "Abe-dam" "Abe-tuntum" "Abe-fita" or "Abe-futu" "Adi-be" "Abubu-be".

Of these the "Abe-pa" variety is said to be the most abundant and is widely distributed all over the Colony. The "Abe-dam" variety is very similar and also abundant; the "Abe-tuntum" fruits are nearly black in colour; the "Abe-fita" variety is very scarce; it bears large fruits with pericarps which are white with large dark red splotches, and yields hard nuts; the oil from this variety is of a characteristic pale canary colour, and differs slightly from the oils of other varieties examined in having a low iodine value, viz 44·5, the usual value being approximately from 55 to 60. "Adi-be" is said to be scarce and to bear long fruits, with small hard nuts and very fleshy pericaps yielding 28 per cent. of oil when extracted by native methods. "Abubu-be" is also scarce; its fruits resemble those of "Abetuntum," but yield 25 per cent. of oil, whilst the fibre in the pericarps is said to be very short.

Group 2.—Fruits small: very fleshy pericarps, with thin soft-shelled nuts. } "Abobo-be."

This is the soft-shelled oil palm of the Gold Coast Colony. It is found in the Eastern and Central Provinces, but is not abundant. The shell of the nut can be readily cracked with the teeth

Group 3.—Fruits large: pericarps brick-red: nuts hard, leaflets joined together at base } "Abe-ohene" or King Palm.

The "Abe-ohene" or "King Palm" is exceedingly scarce, and has the same characteristics as the "King Palm" of Southern Nigeria (*i.e.*, the leaflets are joined together at the base), with which it is probably identical.

It is impossible as yet to correlate all these Gold Coast kinds with the varieties noted in other parts of West Africa, but the "Abobo-be" variety has fruits of medium size with thick pericarps and thin-shelled nuts, which resemble those of the "Lisombé" variety of Kamerun, and from comparison of the two made at the Imperial Institute there can be little doubt that this variety is the same as the "Lisombe." Mr. Evans has stated that "the form known as 'Abobo-be' in this Colony somewhat resembles that described by Dr. Preuss in Kamerun as 'Lisombé,' but I am inclined to think it must be a different species, as the 'Abobo-be' in this Colony is smaller than the other varieties, but has a much thicker fleshy pulp: the 'Lisombé' is said to be a much larger fruit, and Dr. Preuss states that the average weight of the 'Lisombé' fruit (arrived at from measurements of the contents of thirteen bunches) was 10·24 grams, whereas the average weight of 'Abobo-be' is only 6·25 grams."

Reference to the table of analyses in Dr. Preuss's article (*Der Tropenpflanzer*, 1902, 6, 465) shows that the "Lisombé" fruits vary in weight from 5·45 to 10·0 grams, so that the supposed difference referred to by Mr. Evans appears to be based on a misinterpretation of Dr. Preuss's results.

		Group I.								Group II.			Unclassified.
	Variety and number of sample.	Abe-pa 27747.		Abe-dam 27747.		Abe-tuntum 27747.		Abe-fita 25748	Abubu-be 30348.	Abobo-be 27747.	Abobo-be 31137.	"Seedless" 29031.*	Cross between Abobo-be and Abe-dam 27747.
		1.	2	1.	2.	1.	2.	1.	2.	1.	2.	2.	2.
FRUITS: *Dimensions*	Average length, inches	1·55	1·2	1·15	1·15	1·25	1·25	1·5	1·30	1·2	1·05	0·8	1·35
	" diameter, inches	0·95	0·8	0·80	0·7	0·8	0·8	1·25	0·75	0·8	0·65	0·4	0·7
	" weight, grams	12·2	7·0	8·7	5·3	7·7	7·1	—	5·0	6·8	3·45	a=0·5 b=4·4	5·8
Composition	Pulp, per cent.	31	29	41	34	29	36	—	50	63	69	—	51
	Nuts, per cent.	69	71	59	66	71	64	—	50	37	31	—	49
PULP: *Composition*	Moisture per cent.	13·5	16·3	25·5	13·5	38·8	31·1	—	21·7	24	24·1	11·1	23·8
	Oil, per cent., calculated on moist pulp	69·2	65	59·7	68·6	39·4	†48·7	—	62·1	57·5	64·1	76	59·5
	" " calculated on dry pulp	80·0	77·6	80·0	79	64·7	70·5	-	79·3	†75·6	84·4	85	77·6
NUTS: *Dimensions*	Average length, inches	1·2	1·0	(1) 1·0 (2) 0·8	[illegible]	1·0	0·95	1·25	1·0	0·75	0·50	—	0·95
	" diameter, inches ..	0·85	0·7	(1) 1·0 (2) 0·8	0·65	0·7	0·7	0·7	0·63	0·6	0·42	—	0·60
	" weight, grams	8·3	4·1	5·3	3·4	4·8	4·5	—	3·03	2·5	1·1	—	2·8
	" thickness of shell inches ...	—	0·15	—	0·13	-	0·15	0·17	0·08	0·05	0·04	—	0·10
Composition	Kernel, per cent. ...	25	31	31	23	24	28	—	40	54	53	—	42
	Shell, per cent.	75	[illegible]	69	77	76	72	—	60	46	47	—	58
KERNELS: *Dimensions*	Average length, inches ...	0·8	0·7	(1) 0·9 (2) 0·75	0·55	0·6	[illegible]	0·7	0·6	0·55	0·40	—	0·65
	" diameter, inches ...	[illegible]	0·4	(1) 0·6 (2) 0·5	0·40	0·45	0·4	0·35	0·47	0·40	0·35	—	0·40
	" weight, grams	2·1	1·0	1·65	0·8	1·2	1·2	-	1·16	1·4	0·45	—	0·95
Composition	Moisture, per cent. ...	25·7	20·0	20·0	19·6	21·7	22·0	—	21·5	27	—	—	22·2
	Oil, per cent., calculated on moist kernels		31·0		15·5	—	14·0	—	44·1	—	—	—	42
	" " calculated on dry kernels		51·0		51	—	57·0	—	56·6	—	—	—	54

NOTE.—The results of examination recorded in each case under No. 1 are for small samples received preserved in formalin, and under No. 2 for large samples of fruits received packed in damp sawdust: the results for No. 2 are therefore the more trustworthy indication of the *average* size and composition of the fruits in question.

* Out of 30 fruits only [illegible] contained nuts; these were very small and about 0·25 inch in diameter. *a* in this column is the weight of a small fruit and *b* that of a large one.

† Received in somewhat poor condition.

In addition to the varieties described above, the Director of Agriculture in the Gold Coast subsequently transmitted to the Imperial Institute a small sample of a "seedless" oil-palm fruit. This appears to be identical with the "Votchi" of Dahomey, but nothing is yet known as to the extent of its occurrence in the Colony.

Samples of the fruits, nuts, kernels and oils obtained from a number of these Gold Coast varieties of oil palm have been examined at the Imperial Institute, and the results are given in the tables on pp. 517 and 519.

Practical trials of the fruits of five of these varieties have been made in the Gold Coast by Mr. Evans, using ordinary native methods of extraction, and these have given the results quoted below, to which are added, for comparison, the actual percentages of palm oil present in the fruits, as deduced from the analytical results obtained at the Imperial Institute.

	Variety	Palm oil in *whole* fruits as received at the Imperial Institute (calculated).	Yield of palm oil obtained by native methods	Kernels in fruits as received at the Imperial Institute	Approximate thickness of shells of nuts.
		Per cent	Per cent	Per cent.	Inch
Group I.	Abe pa	19	11·2	22	0·15
	Abe dam ...	23	11·2	15	0·13
	Abe tuntum ...	17	13·7	18	0·15
	Abe fita	—	—	—	0·17
	Abubu be ...	31	—	21	0·08
Group II.	Abobo-be ...	44	19·2	20	0·05
	"Seedless" ...	76	38·5	—	—*
Unclassified	Cross between Abe dam and Abobo be ...	31	—	21	0·10

* See foot-note to previous table as regards nuts in this variety.

From the tabulated results it is obvious that "Abobo-be" is superior to all the other Gold Coast varieties, with the exception of the "seedless" kind, in yield of palm oil, and at the same time gives a high yield of kernels, and further, the shells being thin, the nuts are easier to crack. It should be noted, however, that the nuts, and consequently the kernels, are much smaller than those of the other varieties, and although less force is required to crack the nuts, a much larger number must be cracked to obtain the same weight of kernels than is the case with nuts from some of the other kinds of palm fruits. Little or no attention has been given to this point previously, and it would be interesting to know whether a larger amount of kernels could be obtained from the thin-shelled varieties than from the thick-shelled kinds in a given time with the same amount of labour. From the dimensions, appearance and composition of the "Abobo-be" fruits there can be no doubt that they are identical with the "Lisombé" and "A-sog-e-pub" fruits of Kamerun and Southern Nigeria (p. 524) respectively. Of the other varieties there is not very much to choose between the "supposed cross between Abobo-be and Abe-dam" and "Abubu-be," all of which give fair yields of oil and kernels, but have shells of a thickness intermediate between the typical thin-shelled variety "Abobo-be" and the typical thick-shelled variety, "Abe-pa."

"Abe-dam," "Abe-pa" and "Abe-tuntum" are all poor varieties and differ but little in yield of oil and kernels, and it is rather difficult to see how they can be differentiated, since although the colour and shape of the fruits vary it seems that these characteristics are too uncertain to be of much value (Thompson, *Southern Nigeria Gazette*, 1909, No. 38, Suppl. xxv). "Abe-fita" is also a poor variety, and has nuts with thick shells. It is interesting, as it yields a pale-coloured oil slightly different from the others in chemical composition, but as it is rare it is unlikely to be of any special value. The so-called "seedless" variety yields a large amount of palm oil, but it is rare, and it is not known whether it can be grown from the small seeds, which some of the fruits contain. It appears to resemble the "Votchi" variety from Dahomey.

Comparison with the table of analyses on p. 525 shows that in most cases the average weights of fruits from the Gold Coast are smaller than those of similar varieties from Southern Nigeria, presumably owing to less favourable conditions of growth. This is especially noticeable when the fruits of the "Abobo-be" variety of the Gold Coast (weighing from 3·45 to 6·8 grams) are compared with the fruits of the corresponding thin-shelled sort, "A-sog-e-pub," from Southern Nigeria (weighing 12·6 grams). The weights of the Gold Coast fruits approximate to those of the corresponding Togoland varieties as recorded by Fendler (*Arbeiten Pharm. Inst. Berl.* Vol. i, p. 192).

Gold Coast Palm Oils

The results of examination of palm oils prepared in the Gold Coast Colony by the usual native methods from fruits of several varieties of oil palms as well as of oils extracted at the Imperial Institute by light petroleum are given in the following table:—

	Abe-pa.		Abe-dam.			Abe-tuntum.		Abe-fita.		Abobo-be.		"Seedless."		Adjei.
	1.	2.	1.	2.	3.	1.	2.	1.	2.	1.	2.	1.	2.	
Specific gravity at 100/15·5° C.	0·861	0·861	0·862	0·860	0·859	0·863	0·860	0·860	0·859	0·862	0·861	0·860	0·850	0·861
Acid value	5·3	9·8	12·0	2·4	7[illegible]·0	6·0	11·3	9·2	1[illegible]·9	10·8	3·0	19·8	90·1	[illegible]·7
Saponification value.	196·5	197·0	196·5	195·5	199·0	195·5	197·0	198·5	198·5	191·0	195·[illegible]	197·5	199·0	197·0
Iodine value	58·3	50·0	57·8	54·0	59·0	59·[illegible]	49·6	44·5	44·8	61·[illegible]	54·0	55·5	56·5	57·6
Reichert-Meissl value.		—					—	0·2		0·2		—	—	
Titer test	—	—						41·5		43·5	—	—		
Unsaponifiable matter.		—		—		1·0	1·0	1·3		0·6	—		—	

* *Oil extracted at the Imperial Institute by light petroleum.*

With the exception of the "Abe-fita" oil (which is of pale yellow colour and has a low iodine value), the chemical composition of the oils derived from the different varieties of fruits has been found to be the same. The similar investigations of Togoland oils made by Fendler (*loc. cit.*, p. 194) led to the same result

The exports of palm oil and palm kernels from the Gold Coast Colony in recent years are given in the following table:—

—	1909		1910.		1911.	
	Galls.	£	Galls.	£	Galls.	£
Palm oil ...	2 007,296	120,978	2,044,868	161,388	1,610,209	128,916
	Tons.	£	Tons.	£	Tons	£
Palm kernels...	11,598	112,425	14,182	185,058	13,254	175,891

[ADDENDUM.] Since the date of the above report (February, 1910) further samples of oil palm products have been received from the Gold Coast for examination, and the results of this work are summarised in the following paragraphs.

The materials received in recent years from the Gold Coast include fruits of two varieties of oil palm not described above, oil and residual fibre produced in experiments with the Gwira pulping machine, specimens of the fruits used in one of these experiments, and oils obtained in the course of fermentation experiments

"*Adu-be*" *Palm Fruits.*—This consisted of a mixture of large and small fruits, which had been gathered from one bunch.

The large fruits had thick pulp and contained medium-sized nuts resembling those of "Abobo-be" palm fruits (p. 516) with thin shells and globular kernels. The small fruits were narrow and elongated, containing no nuts but only a small fibrous mass at the centre. They resembled immature fruits as found in most heads of palm fruits, but the "embryo" nut was smaller.

The size and weight of the fruits were as follows:—

—	Large fruits			Small fruits.
	Fruits.	Nuts.	Kernels.	
Average length ... ... inches	1·1	0 7	0·50	1·05
Average diameter ... ... ,,	0·8	0·6	0·45	0·40
Average thickness of shell ... ,,	About 0·05 and less			—
Average weight ... ... grams	6 7	2·5	1·1	1·5

A mixture of large and small fruits in the proportion of 2 to 3, as in the sample received, was found to have the following composition: The fruit contained 72 per cent. pulp, 28 per cent. nut and 12·5 per cent. kernel. The pulp of the fruit contained 14·5 per cent. moisture and 62·2 per cent. oil (equivalent to 44·8 per cent in the whole fruit and 72·7 per cent. in the dry pulp). The nuts contained 55 per cent. shell and 45 per cent. kernel. The amount of moisture and oil in the kernels could not be determined owing to the small size of the sample.

This fruit is a thin-shelled variety, which would give a good yield of palm oil and a fair yield of kernels. It would be of interest to know if the relative proportions of large fruits with nuts to small fruits without nuts is naturally the same as in the sample supplied.

"*Abe-dam-Adi-be*" *Palm Fruits.*—This variety derives its name from the fact that the fruits are pale in colour like those of "Abe-dam," and possess a thick pulp like those of "Adi-be." It may be a hybrid between these forms, but both of these varieties have thick, hard endocarps, whilst the present example is practically "shell-less," as mentioned below. So far only one tree of this variety has been seen, which is growing at a village near Aburi.

The sample consisted of somewhat small palm fruits, resembling "Abobo-be" fruits in shape and general structure, except that the kernels in most cases had no hard, woody shell, but only a very thin, brown coat or a thin layer of dark brown fibres surrounding them. A very few of the fruits contained nuts with a very thin, brittle shell, but for practical purposes they may be termed "shell-less." The kernels were small and almost spherical.

The average lengths of the fruits and kernels were 1·25 in. and 0·50 in. respectively: the average diameters 0·65 in. and 0·43 in.; and the average weights 3·95 and 0·75 grams. The proportion of pulp in the fruits amounted to 82 per cent., and it contained 27·7 per cent. moisture and 50·9 per cent. oil (equivalent to 41·7 per cent. in the whole fruits and 70·2 per cent. in the dried pulp). The quantity was too small to allow of determination of the amount of moisture and oil in the kernels. It has, however, been shown by previous analyses that the percentage of oil in the kernels of different varieties of palm fruit only varies between narrow limits (see p. 517).

These palm fruits gave a good yield of oil and a fair yield of kernels. The economic importance of the variety will, however, depend entirely on the possibility of reproducing it from seed.

Experiments with the Gwira Pulping Machine.—An experiment with this machine was conducted in the Gold Coast in 1910. Sixty pounds of fresh palm fruits yielded 15·52 per cent. of oil, 58·33 per cent. of nuts, and 10 per cent. of fibrous residue, the loss being 16·14 per cent. A sample of the oil and one of the fibrous residue, as collected from the machine, have been examined at the Imperial Institute.

The oil was clean, orange-red in colour, and of good quality. It contained only 0·85 per cent. of moisture and 0·03 per cent. of impurity.

The following results were obtained on examination:

Specific gravity at $\frac{100^\circ\text{ C.}}{15{\cdot}5^\circ\text{ C.}}$ . .	0·858
Acid value	10·4
Saponification value	199·7
Iodine value	51·0
Titer test	43·5° C.

This oil had the usual chemical characters of good-quality palm oil. It was of good colour, and free from any appreciable amount of moisture or dirt, and such palm oil would be readily saleable in Europe, at good prices, as "soft" palm oil.

The fibrous residue was found to contain 9·6 per cent. of moisture and 34·2 per cent of oil, or 37·8 per cent. calculated on the dry material. The oil, as extracted by solvents from the fibrous residue, was hard and of pale colour, and consisted chiefly of fatty acids.

Residual fibrous pulp obtained in the extraction of palm oil by the usual native method in Southern Nigeria, examined at the Imperial Institute, contained only 31 per cent. of oil, calculated on the dry material, as compared with 37·8 per cent. in the present instance. The fibrous pulp from Southern Nigeria was obtained in the extraction of palm oil by the usual native method, and it would thus appear that the Gwira machine does not extract as large a proportion of the oil from palm fruits as the native process does. This is probably due to the fact that no pressure is exerted on the pulp in the machine, the oil being merely washed out, whereas in the native process the pulp is squeezed by hand. Some of the oil retained in the present sample of machine-prepared fibrous residue was readily extracted by wrapping the material in a cloth, immersing for a few minutes in boiling water, and wringing by hand.

The bulky, fibrous nature of this residual pulp renders complete extraction of the oil by mechanical means impossible, but it should be easy to obtain a good yield of oil by re-heating the material with water and subjecting it to pressure in simple screw, lever, or wedge presses, or even by hand.

A second experiment was carried out in 1912, the materials employed consisting of equal quantities of the fruits of the "Abe-pa," "Abe-dam," and "Abe-tuntum" varieties. Five lots of fruits, each lot weighing 80 lb., were pulped. The fibre and nuts were washed after coming from the machine, and the oil and water squeezed from the fibre by hand. The yield of oil ranged from 13·75 to 16·25 per cent., and the percentage of fibrous residue from 7·50 to 10·0. A sample, representative of the fruits used in this experiment, and some of the fibrous residue obtained, were received for examination.

The palm fruits were orange-red in colour, in good condition, with thin pulp and thick-shelled nuts. The pulp formed 30 to 31 per cent., and the nuts 69 to 70 per cent. by weight of the fruits: the nuts consisted of 70 per cent. of shells and 30 per cent. of kernels. These proportions of shell and kernel agree with the results obtained for samples of thick-shelled palm nuts previously examined at the Imperial Institute (see p. 517).

The pulp of the fruits as received contained 5 per cent. of moisture, and 72·1 per cent. of oil, equivalent to 75·8 per cent. of oil in the dry pulp. In the case of previous samples of palm fruit examined at the Imperial Institute, the pulp has contained as much as 31 per cent. of moisture, and even this is probably exceeded in the freshly-gathered fruit, so that it is clear that the sample under report had dried considerably during transit to

London. It may be pointed out that the amount of moisture present in the fruits when pressed must be taken into account when comparing the yields of oil in different instances.

The fibrous material was found to contain 10 per cent. of moisture, and 36 per cent. of oil, equivalent to 40 per cent. in the dry fibre. The fibre therefore contained rather more oil than that obtained in the previous experiment with the Gwira machine, and considerably more than the residue obtained by the usual native method of pressing palm fruits (see p. 522). The samples so far examined at the Imperial Institute have therefore not indicated that the Gwira machine extracts as much of the oil from the palm fruits as the usual native method.

Palm Oils obtained in Fermentation Experiments.—An experiment designed to ascertain the effect of fermentation of the fruit on the quantity and quality of the oil was carried out by the Agricultural Department, Gold Coast, in 1912. The yield of oil, as obtained by the Gwira machine was as follows: From fresh fruits extracted on the day of gathering, 10 per cent.; from fruits fermented for eight days before extraction, 11·25 per cent.; from fruits fermented for six weeks, 9·82 per cent. The yield in each case was low, and further experiments are necessary before the results can be taken as decisive.

A sample of each of these oils was received at the Imperial Institute for examination. The oil prepared from fresh fruits and that prepared from fruits fermented for eight days were soft and had the normal appearance of palm oil; that prepared from fruits fermented for six weeks also had the appearance of palm oil, but it was much harder than the other samples.

In order to ascertain the effect of the fermentation on the composition of the oil, the acid values of the three samples were determined. This constant indicates the extent to which the oil has become rancid and "hard." The following results were obtained:—

	Acid value
Oil from fresh fruits	8·4
Oil from fruits fermented 8 days	13·2
,, ,, ,, 6 weeks	103·7

These figures show that the first two are "soft" oils with a low acid value, whilst the third is a "hard" oil with a high acid value. For comparison with the above results the following acid values, recorded for typical "soft" and "hard" commercial palm oils, may be quoted:—

"Soft": Lagos palm oil	25 to 26
"Hard": Congo ..	151 to 167

The value of "hard" oil is much lower than that of "soft" oil, as will be seen by the following prices recently quoted in Liverpool: Lagos, "soft" oil, £31 5s. to £31 7s. 6d. per ton; Congo, "hard" oil, £26 to £26 5s. per ton (April, 1913).

The results of this investigation conclusively show that the effect of allowing palm fruits to ferment for a considerable period is to produce a "hard" oil of much lower commercial value than the "soft" oil prepared from the fresh fruits.

NORTHERN NIGERIA.

Comparatively little information is available regarding the distribution of the oil palm in this Protectorate. Palm oil and palm kernels are produced for local use, but owing to the distance from the coast only small quantities are exported through Southern Nigeria, the export returns being included with those for the latter colony.

SOUTHERN NIGERIA.

Several varieties of oil palm have been observed in Southern Nigeria, and the fruits from those occurring in the Central, Eastern and Western Provinces have been examined at the Imperial Institute. According to Thompson three varieties are known (*Southern Nigeria Gazette*, Suppl., 1909, **4,** p. xxiv.). The following descriptions may be given:—

No. 1. This bears the following native names: "Ope-arunfo" (Yoruba dialect), "A-sog-e-jub" or "Osok-Eyop" (Efik dialect), "Osuku" or "Au-su-ku" (Ibo dialect), "Ivioronmila" (Benin dialect), "Eduege-Eyop" (Ibibio dialect). A thin-shelled variety found in all three provinces, but the proportion in which it occurs varies greatly, rising from 0·2 per cent. in the Western Province to 30 per cent. in the Eastern Province. It is said to give a larger yield of better oil than any of the others found in Southern Nigeria.

No. 2. This is the typical or ordinary oil palm of the country, and bears the following native names: "Ope-pankora" (Yoruba dialect), "Ak-por-ro-jub" or "Okporo-Eyop" (Efik dialect), "Ok-po-ruk-pu" (Ibo dialect), "Udin" (Benin dialect), and "Ikrok-Eyop" (Ibibio dialect). It forms about 60 per cent. of the oil palms in the Eastern Province.

No. 3. This appears to be similar to the "King or Fetish Palm" found in other parts of West Africa, since, like it, the leaflets are in many cases joined together. It is known by the following names: "Ope-Ifa" (Yoruba dialect), "Ogiedi" or "Ogedudin" (Benin dialect), "Af-fia-ko-jub" or "Afia-Okpo-Eyop" (Efik dialect), or "Ojuna" or "O-ju-ku" (Ibo dialect), and "Efiako-Eyop" (Ibibio dialect). It is common near Lagos in the sandy country near the seashore and the lagoons, and is regarded as sacred by Yorubas; the nuts are used by native medicine men for casting lots.

In the tables on pp. 525, 526 are given the results obtained by the examination at the Imperial Institute of fruits, nuts and kernels of varieties from the Central, Eastern and Western Provinces.

From the data given in this table the factors of principal importance to the palm-oil industry may be obtained respecting each variety of fruit, viz., palm-oil content, palm-kernel content and approximate thickness of shells of nuts. As noted already in connection with the analyses of fruits from the Gold Coast, the moisture content of the palm fruits as received at the Imperial Institute from Southern Nigeria may differ considerably from that present in the fresh fruits as used by the natives for preparing palm oil, so that the oil content given in the table on p. 525 does not necessarily represent that of the fresh moist fruits.

Variety and number of sample	Iworonu (Central Province) No. 27959		[illegible] or Au-su-ku (Eastern Province) No. 30185		Ope-pokoro (Western Province) No. 30081.	Idu (Central Province) No. 27959.			Ak-pe-[illegible]-ju or Os-p[illegible]-uk-pu (Eastern Province) No. 30185.		Ogiedi (Central Province) No. 27959.		Af-na ko-jub or O-ju-ku (Eastern Province) No. 30185.	
FRUITS:														
Dimensions Average length, inches	small fruits [illegible] large .. 1·6		1·32		1·2	1·3			1·51		1·5		1·72	
,, diameter, inches	small .. 0·45 large .. 1·15		0·95		0·85	0·85			0·95		0·65		0·90	
,, weight, grams	small .. 3·0 large .. 10·0		12·6		7·4	7·1			12·8		4·3		12·0	
Composition Pulp, per cent.	26		83		36	25			45		53		69	
Nuts, per cent.	74		17		64	75			55		47		31	
PULP:														
Composition Moisture, per cent.	5·5		25·6		25·1	6·3			29·8		7·1		28·6	
Oil, per cent., calculated on moist pulp	67·4		58·7		54·0	66·0			58·2		66·7		54·9	
,, ,, calculated on dry pulp	71		78·9		72·0	70·5			83·1		71·8		76·9	
NUTS	A	B	A	B		A	B	C	A	B	A	B	A	B
Dimensions Average length, inches	small 0·8 large 1·4	—	0·82		0·90	1·0	—	—	1·2	—	0·62	—	1·07	—
,, diameter, inches	small 0·4 large 0·8	—	0·56	-	0·70	0·75	—		0·78	—	0·50	—	0·64	—
,, weight, grams	[illegible]	[illegible]	2·07	2·0	1·0	5·5	4·02	—	7·0	7·0	2·15	small 1·0 large 0·4	4·0	4·5
Composition Kernel, per cent.	—	21	53	40	[illegible]	—	18	—	20	19	—	18	37	25
Shell, per cent.	—	79	47	60	[illegible]	—	82	—	80	81	—	82	63	75
KERNELS														
Dimensions Average length, inches	small [illegible] large [illegible]	-	0·5	—	[illegible]	0·5	—		0·7	—	0·5	—	[illegible]	-
,, diameter, inches	small 0·3 large [illegible]	—	[illegible]	—	0·18	0·30	—	-	0·17	—	[illegible]	—	[illegible]	—
,, weight, grams	—	1·0	1·0	1·[illegible]	1·[illegible]	—	-	[illegible]	1·[illegible]	1·[illegible]		0·4	1·[illegible]	1·1
Composition Moisture, per cent.	7·2	—	18·0	-	—	[illegible]	-	6·7	20·2	—	8·0	[illegible]	[illegible]	—
Oil, per cent., calculated on moist kernels	45·8		—	-	-	—	-	10·7	—		[illegible]	50·[illegible]	-	
,, ,, calculated on dry kernels	52·[illegible]		-	—	-	—	-	[illegible]	—	—	[illegible]	[illegible]	—	—

Note.—Column A gives in each case results of the examination of fruits and nuts [illegible]
Column B gives in each case results of the examination of [illegible]
Column C gives results of examination of pulp kernels [illegible]

These results show that "Ope-pankora" fruits from the Western Province are medium-sized, irregularly-shaped fruits of th common thick-shelled variety, and are evidently a poor variet giving low yields of oil and kernels. Of the three kinds sent fron the Central Province all had evidently dried *en route*, and th results are therefore only approximate and of less value than results from fruits in a natural moist state would have been. Th "Ivioronmila" fruits were in somewhat poor condition, and ver irregular in size and weight; they had mostly thick-shelled nu and a thin pulp, although some of the smaller fruits had somewha thin-shelled nuts. Thompson (*loc. cit.*) classes this as a thin shelled kind: this is evidently not true of all the sample sent to th Imperial Institute The sample of "Ogiedi" fruits containe two kinds, (1) elongated fruits of curious shape with thick pul

Variety	Palm oil in fruits as received at the Imperial Institute (calculated)	Kernels in fruit as received at the Imperial Institute	Approximate thickness of nut shells
	Per cent	*Per cent*	*Inches*
Ope pankora Western Province ...	19	19	0·10
Udin Central Province ...	16	13	0·20
Ak por ro-jub or Ok po-ruk-pu Eastern Province	26	moist, 11·0 dry, 10·5	0·15
Ivioronmila Central Province ...	17	15	nuts from small fruit, 0·05; large fruit, 0·20
A-sog e jub or Au su-ku Eastern Province ...	18	moist 9·0 dry, 7·0	0·06
Ogiedi Central Province ...	35	8	0·07* 0·15†
Af fia ko-jub or O-ju-ku Eastern Province ...	38	moist, 11·5 dry, 7·8	0·08

Small sample of broken shells received from S Nigeria
† Shells of nuts extracted from fruits received from S. Nigeria

and thin-shelled nuts, (resembling those of "Abobo-be" (p. 516 or "Lisombé," (2) fruits with thin pulp and thick-shelled nuts no nuts could be found showing the four eyes, which are said to b characteristic of this variety (*Kew Bulletin*, 1909, 49), but a smal sample of "Ope-ila" palm fruits from Abuleoja examined con tained some nuts with four and even five eyes. It would be interesting to know whether the mixed nature of these samples o "Ivioronmila" and "Ogiedi" fruits and nuts is due to natura variation or accidental admixture of different varieties during col lection. The "Udin" fruits were very similar in appearance to the larger fruits of the "Iviorommla" variety, and do not differ appreciably from these in yield of oil and kernels.

Of the varieties from the Eastern Province the "A-sog-e-jub" or "Au-su-ku" fruits gave the best yield of oil of any of the Southern Nigerian varieties so far examined. The nuts are thin-shelled and yield fair-sized kernels, although the yield of kernels as calculated on the weight of fruit taken is not larger than those of the "Lisombe" and "Abobo-be" varieties, though the fruits are larger, probably owing to more favourable conditions of growth. There can be no doubt that "Abobo-be," "Lisombé" and "A-sog-e-jub" are all of the same type. The "At-fia-ko-jub" or King Palm fruits furnish the same amount of kernels, but a better yield of oil than the typical thick-shelled "Ak-por-ro-jub." The latter resembles in general character the typical thick-shelled "Abe-pa" and "Abe-dam" varieties of the Gold Coast.

Palm oils from Southern Nigeria

A number of these on examination proved to be quite similar in composition to palm oil of commerce, and, as in the case of all the Gold Coast kinds except "Abe-fita" oil, no difference in composition could be detected between palm oils from the different varieties of fruits. The results of examination of the Southern Nigerian palm oils are shown in the following table:—

—	A-sog-e-jub or Au-su-ku	Udin	Ak-po-ro-jub or Ok-po-ruk-pu	Ogiedi	At-fia-ko-jub or O-pu-ku
Specific gravity at 100/15° C. ...	0·859	0·858	0·860	0·859	0·859
Acid value	11·0	17·2	9·7	7·7	9·5
Saponification value	201	199	[illegible]	198	200
Iodine value	49·6	56·3	53·6	54	52·4

[ADDENDUM.] Since the date of the above report (March, 1910) further samples of oil-palm products have been received from Southern Nigeria and these are dealt with below.

The oil-palm products received for examination from Southern Nigeria in recent years have included fruits of a new variety of oil palm and nine samples of palm oil. The latter were collected by Mr. J. H. J. Farquhar, of the Forest Department in Southern Nigeria, in the course of an enquiry into the palm-oil industry of the country.

The results of Mr. Farquhar's enquiry have been embodied in a report, entitled *The Oil Palm and its Varieties*, published recently. Mr Farquhar refers the oil palms occurring in Southern Nigeria to two groups: (i) the King Palm (*Elaeis guineensis* var *Thompsonii*) and (ii) the type form of *E. guineensis*, of which two sub-varieties are recognised.

The King Palm is a well-known form, and has been recognised by most writers as distinct from the ordinary oil palm and by some is regarded as a separate species. It occurs in Southern Nigeria, chiefly in the sandy country bordering the seashore and lagoons, and is common in the vicinity of Lagos It is not found in the dry zone, and is very scarce in the Central Province. Where found at all it constitutes not more than 15 per cent. of the total number of oil palms in the locality. The forms known to the Yorubas as "Ope-Ifa" and to the Benins as "Iyioronmila" are regarded by Mr. Farquhar as belonging to this variety.

The type form of *E. guineensis* is the ordinary thick-shelled variety of West Africa and is apparently identical with the *E. guineensis* var. *macrosperma* of Welwitsch. It includes those palms known to the natives as "Ope-pankora" (Yoruba dialect), "Ak-po-ro-jub" and "Okporo-Eyop" (Efik), "Ok-po-ruk-pu" (Ibo), "Udin" (Benin), and "Ikrok-Eyop" (Ibibio). Mr. Farquhar considers that this palm comprises at least 98 per cent. of the total number of oil palms in Southern Nigeria, and possibly nearer 99·8 per cent.

The first sub-variety of the type form appears to be identical with the *E. guineensis* var. *microsperma* of Welwitsch, the "Abobo-be" palm of the Gold Coast, and the "Lisombé" variety of Kamerun. The palms known as "Ope-aruufo" (Yoruba dialect), "A-sog-e-jub" and "Osok-Eyop" (Efik), "Osuku" and "Au-suk-ku" (Ibo), "Eduege-Eyop" (Ibibio), and "Ogiedi" (Benin), are regarded as belonging to this variety. It is distinguished from the other forms only by the character of its fruit, which is twice as long as broad, and dark claret-brown in colour when ripe, except at the point of attachment, which is yellowish-red; the mesocarp is thick and fleshy, the shell thin, and both nut and kernel are round This palm is considered to be very rare, not exceeding 0·2 per cent. of the total number of palms in Southern Nigeria. It is most common in the Eastern Province and less plentiful in the Central Province, and appears to favour the rich alluvial land of the forest region, which has a heavy well-distributed rainfall.

The second sub-variety includes the "O-ju-ku" palm of the Ibos and the "Af-fia-ko-jub" of the Efiks. It is considered that 1·8 per cent. of the palms of Southern Nigeria belong to this class. The fruit is pale yellow in colour, shading into a coppery hue when ripe; the kernel is larger than in the type, the shell thicker, and the mesocarp thinner and lighter in colour.

Palm Oils.—The palm oils received at the Imperial Institute were typical of those produced in the Eastern Province, and are described in Mr. Farquhar's report as follows:

1. Bad quality; rancid with a bad smell and with dark and green patches: bought as a "soft" oil at Calabar.
2. Bad quality, "mixed" oil, bought at Calabar.
3. Bad quality, "mixed" oil, bought as a "soft" oil.
4. Oil bought as "soft" oil at Calabar.
5. Oil bought as "hard" oil at Calabar.
6. Oil bought as "mixed" oil at Calabar.
7. Fresh oil from Aboada district.
8. Best quality "soft" oil; Eket Opobo.

9. Oil bought as "soft" oil, Oron.

All the samples had the usual colour and appearance of palm oil, and it is therefore unnecessary to describe them in detail. The samples measured about one pint in each case.

It was specially desired to know how these oils would be classified commercially, and, in view of the number of complete analyses of palm oil from Southern Nigeria already made at the Imperial Institute (see p. 527), the examination was confined to this point in the first instance. The classification of palm oil on the market depends mainly on the condition in which it is received, and the two principal factors are:—

(*a*) The percentage of impurities, such as dirt and water, present in the consignment.

(*b*) The "hardness" or "softness" of the oil.

The results of the examination of the samples are given in the following table.—*

Number of Sample.	Moisture.	Dirt	Melting point of oil.*	Acid value	Glycerine.	
					Calculated from acid value	Determined experimentally
	Per cent	*Per cent.*	C.		*Per cent*	*Per cent*
1	0·55	0·14	38–39	91·5	6·25	
2	0·48	0·30	34	51·6	8·10	
3	0·80	0·34	34–35	52·3	8·37	
4	0·86	0·13	30	25·1	9·72	–
5	1·10	0·37	31·5	70·7	7·46	7·2
6	0·94	0·41	36	72·7	7·57	7·3
7	0·26	0·01	29–30	11·1	10·45	10·1
8	0·18	0·02	24	15·6	10·21	
9	1·05	0·92	39–40	[illegible]	5·85	

* *Approximate determinations by open capillary tube method.*

It is clear from these results that all nine samples were satisfactory as regards the percentages of dirt and moisture present, and no serious exception could be taken to any of them on this ground.

The acidity determinations showed that three of these oils (Nos. 4, 7, and 8) had undergone only slight fermentation and would be classed as "soft" oils, whilst four others (Nos. 1, 5, 6, and 9) were highly fermented and would be classed as "hard" oils. The remaining specimens, Nos. 2 and 3, would probably be classed as "mixed" oils, since they were intermediate in acidity between the typically "soft" and the typically "hard" oils. The same classification of the nine oils results from a comparison of their melting-points, but the acidity figures give a much clearer indication of the class to which each oil belongs.

The importance of the distinction between "soft," "mixed," and "hard" oils from a commercial point of view lies mainly in the fact that the inferior "mixed" and "hard" oils, owing to their faulty method of preparation, yield, when used for soap manufacture, less of the valuable by-product, glycerine, than do the "soft" oils, and it is for this reason mainly that they fetch lower prices. The amount of glycerine which can be obtained from an oil or fat can be roughly calculated from the acid value, but as this involves certain assumptions, it was thought desirable in the present instance to check the values thus arrived at by direct determinations of the glycerine in several cases, and the figures obtained in these two ways are given in columns 6 and 7 of the above table.

It is understood that some difficulty has been experienced recently by importers of palm oil owing to the fact that certain West African ports which formerly shipped only "soft" oil have begun to ship "mixed" or "semi-hard" oils.

Mr. Farquhar refers to this matter in connection with shipments of palm oil from Calabar, and explains that this is due to the fact that in recent years the upper reaches of the Cross River have been opened up, and from thence palm-oil, prepared in various ways, now reaches Calabar for shipment. Much of the oil from this area appears to be "hard" or "semi-hard," whereas formerly all the oil shipped from Calabar was "soft." There is no satisfactory simple test by which "soft" and "hard" or "semi-hard" oils may be distinguished in the course of actual trading operations in West Africa, and consequently oil purchased as "soft" oil has in some cases turned out to be inferior "hard" oil when examined in Europe. Examples of this are shown in the series of oils dealt with in this report (p. 529). The remedy seems to lie in encouraging the natives to abandon the fermentation process of extracting palm oil, but unfortunately when fresh fruits are employed the process of extraction is more expensive, as it entails the use of large boiling-pots and the consumption of a good deal of fuel, and these are serious difficulties to the natives in some areas.

Palm Fruit.—A sample of palm fruit known to the Efik people as "Ayara Mbana" was received from Calabar in March 1912. The fruits were large, pale brownish-yellow in colour, and of irregular shape. They differed from ordinary palm fruits in being almost enclosed in a thick, oily perianth; as a rule the perianth of the mature fruit, although enveloping the fruit in a similar manner, is dry and scarious. The shells of the nuts were moderately thick and the kernels rather small.

The average weight of the fruits, nuts, and kernels was approximately 8·9, 3·75, and 1·13 grams respectively. The perianth constituted 21·3 per cent. of the fruit by weight, the pulp 35·8 per cent., and the nuts 42·9 per cent. The pulp contained 8·9 per cent. moisture and 76·1 per cent. oil, equivalent to 27·2 per cent. expressed on the whole fruit and 83·5 per cent. expressed on the dry pulp. The nuts consisted of 70 per cent. shell and 30 per cent. kernel, the latter containing 20·1 per cent. moisture and 43·4 per cent. oil, equivalent to 54·3 per cent. calculated on the dry kernel. The perianth contained 10·6 per cent. moisture and 69·9 per cent. oil, equivalent to 14·8 per cent. expressed on the whole fruit and 78·2 per cent. expressed on the dry perianth.

It will be seen that the fruits as received contained 42 per cent. of palm oil, viz. 14·8 per cent. in the outer pulpy covering (perianth) and 27·2 per cent. in the ordinary pulp adhering to the nuts.

This yield is almost as large as that given by the "Abobo-be" palm fruit of the Gold Coast or the "A-sog-e-jub" variety of Southern Nigeria (see pp. 517, 525). The yield of kernels in the present instance is, however, low, being only 12·9 per cent expressed on the fruits as received.

A variety of palm fruit similar to that under report has been recorded under the name of "Klude" as occurring in the Misahohe district of Togoland (see *Der Tropenpflanzer*, 1904, **8**, 283). The fruit does not appear, however, to have been described as a distinct botanical variety, and it seems not unlikely that it is merely a "sport."

It would be of much interest if the seed of this palm could be grown experimentally in Southern Nigeria, in order to ascertain whether the offspring would produce the characteristic fruits of the parent plant.

The exports of palm oil and palm kernels from Southern Nigeria in recent years are shown in the following table; for the sake of uniformity the quantities of palm oil exported in 1907-09 have been converted from gallons to tons, 243·5 gallons being taken as weighing 1 ton.

—	1907		1908	
	Tons.	£	Tons	£
Palm oil	75,288	1,313,960	75,273	1,154,933
	Tons.	£	Tons	£
Palm kernels	133,630	1,658,292	136,558	1,421,595

—	1909		1910		1911	
	Tons.	£	Tons	£	Tons	£
Palm oil ...	94,441	1,417,163	76,850	1,712,2[illegible]	79,337	1,696,876
	Tons.	£	Tons.	£	Tons	£
Palm kernels	158,849	1,815,967	172,997	2,450,815	176,389	2,571,105

UGANDA.

A consignment of palm fruits of irregular size and shape having a thin pulp enclosing thick-shelled nuts, was received from Uganda in October, 1909. The pulp was very dry, and had mostly been rubbed off in transit. The dimensions and weight of the fruits, etc., were as follows:

—	Fruits	Nuts	Kernels
Length, *inches*	1·3 to 2·0	1·0 to 1·75	0·6 to 0·85
Diameter, *inches*	0·7 to 1·55	0·65 to 1·2	0·4 to 0·6
Thickness of shell, *inches* ...	—	0·1 to 0·35	—
Weight, *grams**	—	3 to 16	0·5 to 2·5

* The nuts consisted of 83 per cent. shell and 17 per cent. kernel, and the latter contained 8·2 per cent. of moisture and 16·3 per cent.

of oil, equivalent to 50·4 per cent. in the dry kernel. The weight of the fruits, the percentages of pulp and nut, and the amount of moisture and oil in the pulp could not be determined, owing to the damaged state of the fruits.

The fruits were received in poor condition, but they evidently belonged to the poorest class of oil-palm fruits, having a thin pulp and thick-shelled nuts, and resembled in type such varieties as the "Abe-pa" and "Abe-dam" from the Gold Coast and "Udin" from Southern Nigeria.

NYASALAND.

A sample of palm fruits from the north end of Lake Nyasa where a limited number of palms occur, was received in March, 1909. The fruits were large, usually with thick-shelled nuts and thin pulp, but two of the fruits examined contained typical thin-shelled nuts. The average dimensions and weight of the fruits, etc., were as follows:—

—	Fruits.	Nuts.	Kernels.
Length, *inches*	1·4	1·0	0·6
Diameter, *inches*	1·0	0·7	0·4
Thickness of shell, *inches* ...	—	0·15	—
Weight, *grams*	12·0	6·2	1·1

The fruits consisted of 49 per cent. pulp and 51 per cent. nuts the percentage of kernels being 8·6. The pulp contained 3·4 per cent. of moisture and 76·9 per cent. of oil, equivalent to 37·6 per cent. in the whole fruit and 79·6 per cent. in the dry pulp. The nuts consisted of 83 per cent. shell and 17 per cent. kernel; the latter containing 6·8 per cent. of moisture and 48·1 per cent. of oil, equivalent to 51·5 per cent. in the dry kernel.

These Nyasaland palm fruits, like those from Uganda, belonged to the class having a thin pulp and a thick-shelled nut. typically represented by such fruits as the "Abe-pa" and "Abe-dam" of the Gold Coast or the "Udin" of Southern Nigeria These varieties, however, give smaller yields of palm oil, as a rule, than the Nyasaland fruits It is of interest to note that two fruits in the present sample had thin-shelled nuts, resembling in this respect the "Abobo-be" variety of the Gold Coast, so that possibly oil palms of this class also occur in small quantity in Nyasaland.

It is understood that the oil palm does not occur in sufficient quantity in Nyasaland to make the extraction of palm oil or palm kernels of commercial interest in the Protectorate. The results now recorded, however, indicate the class of oil palm which occurs in the country.

MOZAMBIQUE.

The oil palm is at present only cultivated on a small scale in the Mozambique Company's Territory in Portuguese East Africa, and supplies are not yet available in large quantities. Two samples of palm nuts from this country have been examined at the Imperial Institute.

The first sample consisted of dry nuts, many of which were covered with dried pulp. The nuts were large and of the ordinary thick-shelled variety, the average dimensions and weight being as follows:—

	Nuts.	Kernels.
Length, inches	1·1	0·65
Diameter, inches	0·8	0·50
Thickness of shell, inches	0·15	—
Weight, grams	6·7	1·6

The nuts consisted of shell 77 per cent. and kernel 23 per cent. The kernels contained 5·5 per cent. of moisture and 50·5 per cent. of oil of normal character, equivalent to 53·4 per cent. in the dry kernel, and were similar in all respects to ordinary commercial samples of palm kernels. If freed from shell and in good condition the kernels would probably realise the current market price of palm kernels.

The second sample closely resembled the first, but gave a rather lower yield of kernels, viz. 19·6 per cent. The approximate average weight of the nuts was 9·3 grams, and of the kernels 1·8 grams.

GENERAL CONCLUSIONS.

Reference was made at p. 510 to the fact that the investigations which have led to the results now recorded were initiated with a view to ascertaining the precise position of the palm-oil industry in British West Africa, and the possibility of introducing more modern methods of exploiting the oil-palm forests. The principal points ascertained may be summarised thus:—

1. There is an abundant supply of palm fruits, and large areas of oil-palm forest still exist almost untouched. There is consequently no fear in the immediate future of a failure in the supply of palm oil and palm kernels even if the crude and wasteful native processes of exploitation are persisted in.
2. Palm oil and palm kernels are still extracted mainly by native methods, and the machinery now available for these purposes seems to have been adopted on a very small scale only, as far as British West Africa is concerned.*
3. Several varieties of oil palm occur in most of the British West African Colonies which produce palm oil, and of these the varieties yielding thin-shelled nuts present distinct advantages, in higher yields of palm oil and in some cases of palm kernels, over those yielding thick-shelled nuts.

There are two directions in which improvement of the palm-oil industry may be looked for in the future, viz. the introduction of machinery for the extraction of palm oil and palm kernels, and the gradual replacement of the ordinary oil palm by varieties giving higher yields of palm oil and kernels.

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* Since the date of this report (February, 1910) considerable progress has been made in the introduction of machinery for extracting palm oil and kernels.

Introduction of machinery.—Most of the machinery so far introduced is too expensive for use by natives, and so long as the industry remains in native hands it is unlikely that machinery will be largely introduced. The natural remedy for this state of things, so far as British West Africa is concerned, would appear to be the installation of central palm-oil factories under either Government or private European control.* The actual collection of the palm fruits would still be carried on by natives, who should be encouraged to sell the fruits to the central factory in their district. This system of central factories has been found to work well for ginning cotton in West Africa, and experiments are in progress for its adoption for cocoa fermentation in the Gold Coast. The same plan has been found to answer well in other countries for such products as tobacco, sugar beet, sugar cane, coarse textile fibres and other materials. The principal difference between the products so far dealt with in this manner and palm fruits is that the former are agricultural materials while the latter is a forest product. In the case of agricultural materials it can generally be arranged that these will be grown in the neighbourhood of the central factory, and the site of the latter is selected with that end in view. This is not so easy to arrange as a rule in the case of forest products, but as regards palm oil the trees yielding it occur in dense masses over large areas, and it should be easy so to place central factories as to avoid transport of the collected palm fruits over considerable distances. With the development of good roads suitable for wheeled transport and the extension of railways this method of working would be rendered still easier. The advantages of such a system would be a great saving in labour, the avoidance of waste such as goes on in the native manufacture of palm oil, and lastly the preparation of a much better quality of palm oil than is at present put on the market.

In such colonies as Sierra Leone, where the cost of labour is relatively high, the introduction of machinery would obviate a serious obstacle to the extension of palm oil production.

The gradual replacement of the common oil palm by better varieties.—This matter presents great difficulties. In the first place there are enormous areas of oil palms still untouched, and in the areas at present worked large quantities of palm fruits are left ungathered. From the point of view even of increased production there is therefore no need to form plantations. At the same time, as has been indicated already, a certain amount of re-planting is done by natives in a haphazard fashion, and there seems to be no reason why this re-planting should not be done with the best kinds. It is, however, not at all easy to decide which are the best varieties. The "Abobo-be" of the Gold Coast and the "A-sog-e-jub" of the Central Province of Southern Nigeria have been shown in the present investigation to give high yields of oil and a good yield of thin-shelled nuts, which can be easily shelled. It should be noted, however, that the kernels from thin-shelled nuts are as a rule smaller than from thick-shelled nuts, so that to get the same yield of kernels more nuts have to be cracked. The saving in labour may not in practice prove, therefore, to be quite so large as has been generally supposed. The "seedless" kind of the Gold Coast is, as Dr. Soskin points out, almost ideal as a source of palm oil, since it merely requires pressing in an ordinary oil-press to give a far higher yield of palm oil than is obtainable from any other palm fruit.[3]

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* This proposal has been carried into effect by several European firms in West Africa.

These varieties cannot, however, be recommended yet for general planting for the following reasons: It is not at all certain that they can be raised true to seed in a new district, and the small experiment made with Lisombé nuts at the Victoria Gardens in Kamerun to some extent supports this view. Further, it is not known what the yield of these good varieties is in comparison with the ordinary oil palm. It is quite possible that they come into bearing later and give a smaller yield of "heads" of fruit. These and other points must be settled by experimental plantations before any recommendations can be safely made regarding the encouragement of these kinds for re-planting in preference to the ordinary oil palm It would seem to be advisable therefore to form experimental plantations of these kinds at a number of places in each colony, and more especially in Southern Nigeria, Sierra Leone and the Gold Coast Colony, so that data may be obtained (1) as to the possibility of raising these varieties of oil palm *without deterioration* in new localities, and (2) as to their actual value in yield per acre of palm oil and kernels. In all cases similar plantations of the ordinary oil palm should be formed in the same districts, so that strictly comparable information regarding these may be obtained In such plantations experiments in crossing varieties might also be carried out. Between the rows of oil palms maize might be grown as a catch crop as suggested by Adam.

The Inspector of Agriculture for West Africa has suggested that such plantations of oil palms might be formed and separated from each other by plantations of *Funtumia elastica*, the latter being utilised for the carrying out of tapping and other experiments, which are much needed. This plan would have the obvious advantage of enabling series of observations to be carried out on two very important West African industries with the minimum expense for the necessary European supervision. The plantations would have the further advantage of serving to educate natives in two important branches of planting work, and with this end in view the plantations should be worked on modern lines, palm oil and palm kernels being extracted by machinery, and the refuse being returned to the plantations as manure. Similarly the rubber plantations could be utilised for instructing natives in methods of tapping trees and preparing rubber.

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[3] Farquhar has suggested recently (*loc. cit.*) that the so-called seedless varieties may be merely incompletely developed palm fruits.

COPRA.

GOLD COAST.

Two samples of copra were forwarded from Accra in September, 1910.

One sample consisted of fair-sized pieces of dirty copra, apparently prepared from small nuts.

The second sample was also very dirty, and in smaller pieces than sample No. 1. The material had an unpleasant smell and was in poor condition.

The samples yielded respectively 65·7 and 66·6 per cent. of oil, which are normal yields for well-dried copra.

The materials were submitted to brokers, who reported that both samples were of poor quality. They valued No. 1 at £18 17*s.* 6*d.* to £19 per ton, and No. 2 at probably £5 less, with copra from the Straits Settlements at £23 10*s.* per ton (December, 1910). They added that if proper attention were given to the preparation of African copra it would realise a much higher price than at present.

The inferior quality of these samples appears to have been caused by lack of care in drying the material. It seems probable that the copra was allowed to get wet during the course of preparation and, in consequence, its commercial value was considerably decreased.

NORTHERN NIGERIA.

This sample was received in June, 1911.

It was labelled "Copra prepared from coconuts gathered at Aiere, near Kabba," and consisted of pieces of coconut shell with portions of the kernel still adhering more or less firmly to them. The portions of the kernel were somewhat mouldy.

The kernel detached from the shell yielded 67·0 per cent. of oil and contained 4·3 per cent. of moisture. The oil possessed the usual characters of coconut oil and was not submitted to detailed examination.

The present sample was not copra in the commercial sense, and it was not submitted to brokers for valuation. The results of the examination show, however, that copra of good and readily saleable quality could be prepared from the coconuts which furnished this material.

SOUTHERN NIGERIA.

This sample of copra was received in March, 1910.

It weighed 5¼ lb. and consisted of shelled coconuts, cut in half and dried. It was in very good condition, the inner surfaces of the nuts being only slightly brown and quite free from mould. The material was not rancid in odour or taste. As the copra was normal and obviously of good quality no analysis was made.

The material was submitted for valuation to soap manufacturers and to brokers. The manufacturers reported that the copra was quite equal in appearance to the best grades of Ceylon produce, but that the oil obtained from it, whilst of good colour and odour, contained a higher percentage of free acids than Ceylon oil. The manufacturers added that there is not the slightest doubt that if copra can be supplied from Southern Nigeria in the condition of this sample it will find a ready market at high prices.

The brokers described the copra as a very good sample, and stated that there would be a good sale for it in this country.

The best qualities of copra were quoted on the London market on the same date (July, 1910), as follows:—

Australian sun-dried, £21 10*s.* to £21 12*s.* 6*d.* per ton.
Singapore, £22 7*s.* 6*d.* to £22 10*s.* per ton.
Federated Malay States, £23 per ton.
Ceylon, £26 17*s.* 6*d.* per ton.
Zanzibar, £22 5*s.* per ton.
Manila, £22 10*s.* per ton.

African copra was quoted in Liverpool at £18 10*s.* per ton for fine quality material on the same date.

COCONUT OIL.

SOUTHERN NIGERIA.

This sample was forwarded to the Imperial Institute from Calabar in January, 1910. It consisted of a white, solid, crystalline fat, having the characteristic odour of coconut oil; a small quantity of vegetable impurity was present. On melting the fat a faint "burnt" smell became apparent. On analysis the following results were obtained:—

	Present sample.	Commercial coconut oil (Lewkowitsch).
Specific gravity at 100° C. 15·5° C.	0·870	0·874
Acid value	0·5	—
Saponification value	262·0	246·0 to 268·4
Iodine value	7·0	8·0 to 9·32

The pure white colour and low acid value of this sample showed that it was carefully prepared. The small amount of impurity present could be removed by straining the melted oil. Care should however be taken not to overheat the oil, as this tends to produce the "burnt" smell noticed in the present instance.

Coconut oil of the quality of this sample would, if quite clean, be readily saleable at the current market price, which varied between £42 10*s.* and £45 per ton at the date of report (April, 1910).

CEYLON AND WEST INDIES.

Two samples of coconut oil were forwarded to the Imperial Institute by the Imperial Commissioner of Agriculture for the West Indies in December, 1904, in order that their value as preventives of fouling in rifles might be determined in comparison with that of the oil specially issued for this purpose by the Army authorities.

The two samples of coconut oil, one labelled "from Trinidad" and the other "from Ceylon," were practically identical in appearance, taste and odour. They were submitted to chemical examination and furnished the following results:—

	Coconut oil from Ceylon.	Coconut oil from Trinidad.
Specific gravity at 100°/15·5° C. ...	0·8787	0·8702
Melting-point	26° C.	24·5–25·5° C.
Free fatty acids (calculated as oleic), per cent.	3·35	4·85
Saponification value	260	262
Iodine value	9·0	8·2
Hehner value	85·6	85·9
Reichert-Meissl value	7·15	7·26

These figures, which agree well with the recorded constants of coconut oil, show that the two samples are practically identical in composition, the only notable difference being that the sample from Trinidad contains more free fatty acid than that from Ceylon and might on that account be considered rather less suitable for the purpose indicated.

In these circumstances it seemed desirable to institute practical trials with the two samples of coconut oil, and, with the consent of the Chief Superintendent of Ordnance Factories, a number of tests have been made at the Royal Small Arms Factory at Enfield for the purpose of comparing the samples with each other and with the service rifle oil. The report furnished by the Superintendent of the Small Arms Factory upon the results of these tests states that the two samples of coconut oil gave identical results when applied to rifle barrels in order to prevent fouling. With reference to the value of the coconut oils compared with the service rifle oil, he reports as follows: "It is found that, as a protective coating for a short period, the coconut oil shows to slight advantage as compared with the rifle oil more especially when applied to the surface of the barrel after that surface has been thoroughly cleaned with hot soda and water and dried When, however, the barrel was not cleaned out with soda and water after firing, and was then treated with the competing oils, the coconut oil appeared somewhat better at the end of the first seven days of keeping; but, after 14 days, the rifles treated with service rifle oil were in the better condition, and after a month a large amount of fouling had appeared in the barrels treated with the coconut oil, whilst those treated with the service rifle oil remained bright and clean. It therefore appears clear that this oil is inferior for the purpose of preserving rifle barrels to the service rifle oil."

"SHEA" NUTS AND BUTTER.

A considerable amount of attention has been given to "Shea butter" in recent years as a raw material for the manufacture of soap and candles, and also for the production of edible fats; and, as a result, interest in the possibility of increasing trade in this product has been aroused, particularly in West Africa, whence the commercial supply of the "nuts" and butter is derived at present.

The following table shows the exports of Shea nuts and Shea butter from Southern Nigeria in recent years:—

—	1909.		1910.		1911.	
	Tons.	£	Tons.	£	Tons.	£
Shea nuts	9,728	78,029	4,461	43,510	3,629	35,518
Shea butter	309	5,230	340	6,804	218	1,978

The specimens of these products now dealt with have been received from the Governments of Northern and Southern Nigeria, the Gold Coast, the Sudan, Uganda, and in part from the Niger Company.

SOUTHERN NIGERIA.

Shea Butter. This was received from Lagos in July, 1905, and consisted of two packages of Shea butter, each weighing about 21 lb. The butter was soft, of pale greenish-yellow colour, and possessed a slight characteristic odour.

Shea Nuts.—Two samples were received in October, 1905, and two in January, 1906.

(1) One of these was labelled "Tengba," and consisted of 50 lb of small, nearly black seed-kernels many of which were pierced by insects.

(2) The second was labelled "Bomo," and consisted of 50 lb of small, dark brown seed-kernels.

(3) A third sample consisted of large kernels, which varied in colour from light to dark brown. Many of the kernels had been attacked by insects.

(4) A fourth was described as "kiln-dried Shea nuts," and consisted of small light brown kernels, only a few of which had been attacked by insects. The last two samples represented the material as usually imported into this country.

The percentages of fat in the four samples of kernels were determined by extraction with light petroleum, with the following results:—

No. of Sample.	Percentage of fat in the kernels.
1	54·5
2	48·0
3	41·4
4	46·2

The sample of Shea butter forwarded from Lagos, and the fats extracted from samples of nuts Nos. 3 and 4 referred to above, were examined chemically. It was thought that a comparison of the two latter specimens would indicate whether the kiln-drying had affected the chemical composition of the fat. The results are given in the following table:—

—	Shea butter from Lagos.	Fat from untreated kernels No. 3.	Fat from kiln-dried nuts No 4.
Specific gravity at $\frac{100° C.}{15·5° C.}$	0·862	—	—
Acid value	18·0	33·9	26·2
Saponification value	179·0	181·2	180·2
Iodine value	58·7	59·4	55·8
Hehner value	96·5	—	—
Unsaponifiable matter ...	1·7	—	—
Titer test	52·0° C.	—	—

It will be seen that these results are in general agreement, the only considerable difference being in the acid values.

A comparison of the figures for the fats extracted here, shows that the kiln-dried kernels contain a lower percentage of free fatty acids than the other specimen.

Northern Nigeria.

Early in 1908 two specimens of nuts, labelled "Giddauchi" and "Eko" respectively, were received from Northern Nigeria. These were identified at Kew as seeds of "forms" of *Butyrospermum Parkii* (the Shea butter tree). The seeds presented considerable difference in size, the "Eko" sort ranging from 1·5 to 2·5 inches in length, whilst the "Giddauchi" variety was about 1·4 inches long on the average. These differences are of some interest in view of Chevalier's recognition (see *Bulletin of the Imperial Institute*, 1908, **6**, 449) of several varieties of the Shea butter tree. The results of the examination of the two kinds are as follows:—

	Giddauchi nuts.	Eko nuts.
Kernels: Yield of fat, per cent.	48·6	52·4
Fat: Specific gravity at $\frac{99° C.}{15° C.}$	0·8691	0·8671
Acid value	7·6	18·2
Saponification value	181·5	182·8
Iodine value	62·0	57·7
Hehner value	91·2	94·6
Reichert-Meissl value	2·6	1·84
Unsaponifiable matter	6·3	7·0

The principal difference to be noted is in the higher proportion of unsaponifiable matter in the fats from these kernels received direct from Northern Nigeria than in those obtained from kernels as imported from Southern Nigeria and in the native-prepared Shea butter. It is stated, however, that in commercial samples of Shea butter and Shea oil (the product expressed from the kernels in Europe) as much as 10 per cent. of unsaponifiable matter sometimes occurs.

GOLD COAST.

Shea nuts.—This sample, labelled "Shea nuts prepared by natives of the Northern Territories," was received in September, 1911, and consisted of clean, rather small Shea kernels, in good condition.

It yielded on extraction 51·2 per cent. of fat as compared with 46·2 to 54·5 per cent. in the case of previous samples examined at the Imperial Institute. The fat had the usual characters of Shea butter.

These Shea kernels should realise the current market price, viz., £10 10*s*. per ton in Liverpool (March, 1912).

Shea butter.—This sample, labelled "Shea butter prepared by natives of the Northern Territories," was receive in September, 1911. It consisted of solid, greyish, cream-coloured fat, with a pleasant odour and apparently free from dirt. A small amount of colourless insoluble matter was present, and was removed by filtration of the melted fat before analysis.

The following results were obtained:—

	Present sample.	Previous samples examined at the Imperial Institute.
Specific gravity at 100°/15·5° C.	0·864	0·859 to 0·869
Acid value	5·3	7·6 to 33·9
Saponification value .. .	183	179 to 181·6
Iodine value	58·7	56 to 63

This Shea butter resembled previous samples examined at the Imperial Institute, but had a slightly lower acid value, probably owing to more careful preparation. Similar fat would be readily saleable in Europe at the current rates, viz., £28 5*s*. per ton in Liverpool (March, 1912).

SUDAN.

In the Sudan the nuts and butter are known as "Lulu" nuts and oil. Samples of the oil and nuts were received in May, 1906, and October, 1907, respectively.

Lulu Nuts.—These were smaller and rounder than those received from West Africa, but otherwise were similar in appearance. The proportion of shell to kernel was approximately as 1 : 2.

The kernels yielded 47·2 per cent. of very pale yellow fat, as compared with 46·4 to 52·4 per cent. of fat obtained from the Nigerian samples. On examination this gave the following results:—

Specific gravity at $\frac{99° \text{ C.}}{15° \text{ C.}}$ ...	0·8594
Saponification value	181·0
Iodine value	62·9
Hehner value	91·9
Reichert-Meissl value .. .	1·4
Unsaponifiable matter .. .	4·3

Lulu Oil.—This consisted of the solid fat, which had a dull, greyish colour, quite different from the pale yellow colour of the West African product. On melting and filtering, a considerable quantity of suspended matter was found to be present, but the filtered "butter" still retained its original colour, and appeared to be rather softer than the samples of Shea butter from West Africa, which have been examined at the Imperial Institute. From the appearance and smell of the specimen it seemed possible that the fat had been overheated in the process of extraction from the seeds.

The fat was submitted to chemical examination, and the results obtained are given in the following table:—

Acid value	10·7
Saponification value	184·6
Iodine value	56·0
Titer test	51·8° C.

The constants found for this sample of "Lulu oil" from the Bahr-el-Ghazal are in general agreement with those obtained at the Imperial Institute for samples of Shea butter from other sources, and also with the results recorded by Dr. Beam for two other Sudanese specimens.

The dull greyish colour of this sample of "Lulu oil" from the Sudan might possibly create a prejudice against it, but this defect could probably be easily overcome by more careful preparation.

Shea butter is used in the manufacture of candles, and also to some extent in soap-making, although the large amount of unsaponifiable matter, which it sometimes contains, is said to render it unsatisfactory for the latter purpose. The high percentage of free fatty acids renders the fat unsuitable for lubricating purposes.

Refined Shea butter is said to have been employed recently especially on the Continent, for use in the manufacture of butter substitutes, and for other edible products, but it is difficult to obtain definite information on this point. An analysis made at the Imperial Institute of one of these products indicated that Shea butter was at least an important component. Its application for these purposes should render it possible to obtain a higher price for the fat than soap and candle makers could offer.

A sample of the Shea butter from Lagos was submitted to a firm of brokers in Liverpool, who reported it to be of the same quality as that usually received from the Niger. The value of Shea butter for candle- and soap-making is usually about the same as that of soft palm oil, such as Bonny or Calabar, the price of which at the date of the report (November, 1907) was £24 5*s*. to £24 10*s*. per ton. The brokers stated that there is a fair demand for Shea butter, and consignments are readily saleable.

UGANDA.

Shea Kernels. This sample, labelled "Kernels of *Butyrospermum Parkii*," was received in October, 1911. The kernels were in good condition and had the usual appearance of Shea nut kernels.

The sample yielded 49·9 per cent. of solid, creamy yellow fat. Previous samples of Shea nut kernels examined at the Imperial Institute have yielded from 46·2 to 54·5 per cent. of fat.

These Shea nut kernels, if exported from Uganda to the United Kingdom in good dry condition, would fetch the current market rate, viz., £10 10s. per ton in Liverpool (February, 1912).

SEEDS OF *MIMUSOPS* SP.

SOUTHERN NIGERIA.

This product is of interest, since the nuts closely resemble Shea-nuts in appearance but are usually somewhat larger. The botanical name of the plant is not known with certainty, but from the specimens sent to Kew, it appears to be a species of *Mimusops*, probably *Mimusops Djave*, the seeds of which are known to yield a similar fat (*Rev. Fett. Harz. Ind.*, 1908, **15**, 78 and 106).

The sample examined was received in 1906, and consisted of nuts of light brown colour, about 2 inches long and 1–1½ inches in diameter, with blunt-pointed ends. The shells were smooth, hard and shiny, except on one side, which bore a rough broad scar running from end to end; they were easily broken and separated from the kernel. The latter varied in colour from cream to brown, possessed a curious fruity odour and an unpleasant, bitter taste. The kernels formed 62·7 per cent. by weight of the whole nuts.

The yield of fat on extraction by solvents was 60·2 per cent. from the kernels, corresponding to 37·7 per cent. from the whole nuts. The fat was solid at the ordinary temperature, nearly white, and resembled Shea butter. It gradually developed a slightly rancid odour on exposure to the air. On examination it gave the following results:

Specific gravity at $\frac{100^\circ C.}{15{\cdot}5^\circ C.}$	0·860
Acid value	25·3
Saponification value .	187·6
Iodine value	56·2
Hehner value	95·4
Reichert-Meissl value . ..	nil.
Unsaponifiable matter	2·6 approx.
Titer test	47·8° C.

The kernels would probably be of about the same value as Shea kernels (see above). The "constants" of the fat correspond closely with those of Shea butter.

BACO OR ABAKU NUTS.

(*Dumoria Heckeli*, A. Chev.)

GOLD COAST.

This sample was received in 1909. It was labelled "Baco (Abaku) nuts" and consisted of large, pale brown nuts with thick, hard, woody shells. The kernels were in most cases mouldy. The nuts consisted of shell 65, and kernel 35 per cent.

The kernels contained 60·5 per cent. of fat, corresponding to 21 per cent. from the whole nuts.

The fat was solid and of a creamy white colour, resembling that from the *Mimusops* nuts from Southern Nigeria (see above).

Specific gravity at 100°/15·5° C.... ...	0·855
Acid value	34·7
Saponification value	188·4
Iodine value	51·3
Titer test	51·2° C.
Unsaponifiable matter	1·3

A firm of soap-makers, to whom these nuts were submitted, reported that the fat would be of about the same value for soap-making as middling quality palm oil. The kernels have an intensely bitter taste, so that the cake left after the extraction of the fat would not be suitable for use as a feeding-stuff. Since the kernels appear to become mouldy when left in the shells and as the latter would be of no value except for fuel, the nuts should be shelled locally and the kernels dried before shipment. The firm added that the dried kernels, in good condition, would be worth about £13 per ton in England (February, 1910).

BASSIA KERNELS AND FATS.

In the last few years there has been a remarkable rise in the prices of almost all oil-seeds, oils and fats. This is to be attributed in part to the increase in the demand for oils and fats for edible purposes, principally as salad and cooking oils, butter substitutes, chocolate fats and cooking fats.

One of the most promising sources of hard vegetable fat for edible purposes is the seeds of the various species of Bassia (N.O. Sapotaceæ) occurring commonly throughout the East Indies, and already imported into Europe under the name of "mowra" seeds. Seeds of *Bassia* spp. appear also to come on the market as "illipe seeds," but this name is undoubtedly also now applied in commerce to seeds derived from genera other than Bassia. There is a good deal of confusion as to the botanical origin of the seeds known commercially by these names, and the Imperial Institute has endeavoured to obtain for examination authentic samples from India, Ceylon, Borneo and elsewhere, of the Bassia and other Sapotaceous seeds which come into commerce, with a view to obtaining definite information as to the relative values of the kernels of the different species as sources of fat. These enquiries are not yet completed, but as a considerable amount of information has been accumulated it seems worth while to place this on record.

For a detailed account of the chemistry of the Bassia fats see "The Composition of Bassia Fats," by R. G. Pelly (*Journ. Soc. Chem. Ind.*, 1912, **31**, 98).

India.

The materials received from India have included specimens of the fruits, seeds, kernels and fats of *Bassia latifolia*, *B. longifolia* and *B. butyracea*. According to Sir George Watt (*The Commercial Products of India*, London, 1908, p. 116) *Bassia latifolia* is generally known in India under the vernacular name "mahua," "mahwa" or "mowha," but is also known in some parts as "illupei" or "illupai," the former being Hindustani and the latter Tamil names. The same names are also applied to *Bassia longifolia* in India, but since this species occurs only in Southern India it is more commonly called by its Tamil names "illupei" or "illipi." It is not safe to assume therefore, as is done by some authorities, that the "mowra" or "mahua" seeds of India are derived from *B. latifolia* and the "illipi" seeds from *B. longifolia*, though this is doubtless generally true. *Bassia butyracea* is known in India as "phulwara," and the solid fat obtained from the seeds is called "phulwa." *Bassia latifolia* occurs in the forests of the central tracts of India, from Western Bengal, Oudh and Kumaun to Gujarat, Kanara and Burma, up to altitudes of 4,000 feet, and is often cultivated. In Southern India it is replaced by *B. longifolia* from Konkan southwards. *Bassia butyracea* occurs in the Sub-Himalayan tracts, from the Ganges to Bhutan, and ascends to altitudes of 15,000 feet. Considerable quantities of fat are expressed in India from the kernels of all three species, and are eaten either as such or are used to adulterate "ghi."

According to the Indian trade returns, "mowra" seeds have been exported in the following quantities and values in recent years:

—	1907–08	1908 09.	1909-10.	1910 11.
Cwts.	795,196	407,272	781,[illegible]37	415,662
Rupees*	44,56,383	24,92,415	16,71,329	31,10,352

* 1 *rupee* = 1s. 4*d*.

Bassia latifolia.

No. 1. "*Bassia latifolia* seed from Nagpur, Central Provinces." The sample consisted of hard, pale reddish-brown half-kernels, which had evidently been dried. The kernels yielded 46·0 per cent. of soft, pale yellow fat.

No. 2 "*Bassia latifolia* fat from the Central Provinces." This consisted of dirty olive-green fat, possessing an unpleasant odour and containing a large quantity of dirt. After filtering, the fat was orange-yellow in colour and of soft consistence.

No. 3. "*Bassia latifolia* fruits from the Central Provinces." The sample consisted of fruits and seeds in the proportion of 2 to 1. The fruits were brownish-black, oval, about $\frac{7}{8}$ inch long, and had hard, thin pericarps. Each fruit contained from 1 to 3 seeds, which had thin, shiny, loosely-fitting husks of brown or yellow colour. The kernels were chocolate-brown, and in most cases were covered with a dust-like yellow fungus.

The fruits, which weighed about nine to the ounce, consisted on the average of 48 per cent. pericarp and 52 per cent. seed. The kernels formed 71·6 per cent. of the weight of the seeds, and contained 33 per cent. of fat, equivalent to a yield of 23·6 per cent. on the whole seeds, or 12·2 per cent. on the fruits. This yield of 33 per cent. from the kernels is unusually low, possibly because the seeds were immature.

The fat extracted from the kernels by light petroleum was yellow, soft at ordinary temperatures, and had a pleasant taste and odour.

The results of examination of the fat of *B. latifolia* are shown in the following table, together with results obtained by previous observers:—

—	Fat from Sample No. 1.	Sample of fat No. 2. Prepared in India	Fat from Sample No. 3	Results recorded previously for fat prepared in India (Crossley and Le Sueur)
Specific gravity at $\frac{100°\text{C.}}{15·5°\text{C.}}$	0·857	0·870	0·862	0·894 to 0·898
Acid value	—	20·0	(See text below.)	4·8 to 70·8
Saponification value ...	189·8	194·4	188·3	187·4 to 194·0
Iodine value	57·6	76·8	61·5	53·4 to 67·85
Hehner value	94·2	86·7	96·4	94·7 to 95·0
Reichert-Meissl value ...	0·2	1·0	0·9	0·44 to 0·8
Unsaponifiable matter ...	2·0	1·7	—	—
Titer test	43·2 C.	36° C.	46 C.	—

* Determined at 100/100 C.

The fat extracted from the seeds enclosed in the fruits of sample No. 3 had an acid value of 31·8, whereas that extracted from the loose seeds in the sample had an acid value of 41·8.

From the high iodine value and low titer test of the fat prepared in India (sample No. 2), it seems possible that only the more liquid portion of the fat was extracted, or that possibly oil had been added by the native workers to facilitate the expression of the fat from the ground seed.

The fat of *Bassia latifolia* extracted from the kernels by means of light petroleum was found to contain glycerides of oleic, stearic and probably palmitic acids. From the iodine value of the fat, the glycerides appeared to be present in the following proportions: olein 66 per cent.; stearin and palmitin together, 34 per cent.

It has been stated by Lewkowitsch (*Oils, Fats and Waxes*, London, 1909, Vol. II. 129) that palmitic acid is the chief constituent of the solid acids in *B. latifolia* fat, but in the fat extracted from sample No. 3 nearly half of the solid fatty acid was stearic acid, which was readily isolated in a pure state.

Bassia longifolia.

No. 1. "*Bassia longifolia* fruits from Taliparamba, Madras." The fruits were blackish in colour and almond-shaped, containing sepia-coloured seeds with brown kernels, many of which were in a powdery condition. The length of the fruits varied from 1·0 to 1·3 inches. The fruit consisted of outer husk 33 per cent.; inner husk 20·5 per cent.; kernel 46·5 per cent. The kernels yielded 55·3 per cent. of soft yellow fat.

No. 2. "*Bassia longifolia* fat from Taliparamba, Madras." The sample consisted of dirty yellowish fat, which after filtering was pale yellow in colour.

No. 3. "*Bassia longifolia* kernels from the Palur Agricultural Station, Madras." The sample consisted of brown kernels resembling those contained in the fruits of sample No. 1. The kernels yielded 57·8 per cent. of a soft yellow fat.

The fat of *Bassia longifolia* was examined with the following results; those recorded by previous workers are given for comparison.

	Fat from Sample No. 1.	Sample of fat No. 2. Prepared in India	Fat from Sample No. 3	Results recorded previously (De Negri and Fabris).
Specific gravity at $\frac{100° \text{ C.}}{15·5 \text{ C.}}$	0·856	0·864	0·861	—
Acid value		5·0	19·7	—
Saponification value ...	202·7	198·2	195·3	188·4
Iodine value	54·8	60·0	60·0	50·1
Hehner value	—	87·4	95·5	94·7
Reichert-Meissl value ...	—	3·6	2·35	—
Unsaponifiable matter ...	2·2	2·1	1·4	—
Titer test	—	36° C.	45° C.	39·7 to 40·3 C.

The results of analysis of the fat from sample No. 3 differ somewhat from those for samples Nos. 1 and 2 and from those recorded by previous investigators, including Menon (*Journ. Soc. Chem. Ind.*, 1910, **29**, 1429). It should be pointed out, however, that the fat sent from India (sample No. 2) was dirty and had been badly prepared, whilst that extracted at the Imperial Institute from sample No. 1 was obtained from a specimen of fruits weighing only 10 oz., and can therefore hardly be regarded as representative.

The fat from sample No. 3 was found to contain glycerides of linoleic, oleic, stearic and palmitic acids. The proportions of the glycerides of the unsaturated acids (olein and linolein) and those of the saturated acids (stearin and palmitin) were about 60 per cent. of the former and 40 per cent. of the latter. The glycerides of oleic and linoleic acids appeared to be present in the proportion of approximately 6 to 1, and the fat would therefore contain about 9 per cent. of linolein.

Bassia butyracea.

No. 1. "*Bassia butyracea* fruits from Kumaun, United Provinces."

No. 2. "*Bassia butyracea* seed from Gonda Division, Eastern Circle, United Provinces."

No. 3. "*Bassia butyracea* seed from Gonda Division, Eastern Circle, United Provinces."

No. 4. "*Bassia butyracea* seed from Kumaun Division, Eastern Circle, United Provinces."

No. 5. "*Bassia butyracea* seed from Kumaun Division, United Provinces."

No. 1 consisted of blackish, oblong fruits, about 1¼ inch in length, with thick, soft, sugary pericarps; they possessed a characteristic sweet smell. Each fruit contained one seed with a brown, shiny, close-fitting husk and a brownish-white kernel.

Nos. 2, 3, 4 and 5 consisted of seeds resembling those contained in the above fruits.

The fruits of No. 1 were composed of pericarp 71·7 per cent. and seed 28·3 per cent. These seeds and those of samples 2, 3 and 5 were found to be constituted as follows:—

Number	Composition of seed.		Yield of fat.	
	Husk.	Kernel.	On weight of kernel.	On weight of whole seed.
	Per cent.	*Per cent.*	*Per cent*	*Per cent*
1	30	70	60·0	42·0
2	23	77	61·2	47·1
3	31	69	63·1	43·5
5	34	66	66·9	44·2

The fat of *Bassia butyracea* as extracted from samples 1, 2 and 3 at the Imperial Institute was a hard, white solid at ordinary temperatures, and possessed a pleasant taste and smell. That extracted from sample 5 was hard and of pale buff colour.

No. 6. "*Bassia butyracea* fat, Gonda Division, Eastern Circle, United Provinces." The sample consisted of a pale yellow fat containing a large quantity of crushed seed. After filtering, a hard, pale buff coloured fat was obtained.

The results of examination of the fat of *Bassia butyracea* are given in the following table:—

	Fat extracted from sample			Sample No. 6. Fat prepared in India.	Results recorded previously (Crossley & Le Sueur).
	No. 1.	No. 2.	No. 5.		
Specific gravity at 100°C./15·5°C.	0·867	0·856	0·857	0·862	0·897*
Acid value	2·6	59·6	—	20·7	16·44
Saponification value ...	197·9	200·0	199·3	195·3	190·8
Iodine value	42·1	39·6	37·6	42·7	42·1
Hehner value	95·7	96·6	—	94·6	94·8
Reichert-Meissl value ...	0·9	nil.	—	4·3	0·44
Unsaponifiable matter ...	—	2·2	2·8	2·8	—
Titer test	50·8°C.	51·5°C.	—	48·2°C.	—

* At 100° C./100° C.

The results obtained at the Imperial Institute agree closely with one another. The saponification values of all four samples are, however, higher than that found by Crossley and Le Sueur, but they agree with that recorded recently by Menon (*loc. cit.*).

The fat of *Bassia butyracea* is somewhat different in character from those of *B. longifolia* and *B. latifolia*, being of lighter colour and harder, and having a higher titer test. It was found to contain glycerides of oleic and palmitic acids, which, calculated from the iodine value of the fat, appeared to be present in the proportion of about 46 per cent. of olein to 54 per cent. of palmitin. The unsaponifiable matter could not be isolated in sufficient quantity for detailed examination. In this and the preceding cases it is semi-crystalline and gives the characteristic reactions of the phytosterols.

CEYLON.

The only species of Bassia represented in the samples from Ceylon is *B. longifolia*, which occurs commonly in the forests of the dry region of the island, but is much rarer, and probably always planted, in the moist low country. *B. latifolia* has been recorded several times for Ceylon, but according to Trimen (*Handbook of the Flora Ceylon*, 1895, Part III, p. 79) *B. longifolia* was without doubt intended.

In Ceylon the plant is known as "Mi" or "Mee" (Sinhalese), but the Tamil name "Illupai" is also employed.

Several samples of the seed and fat were received recently at the Imperial Institute from Ceylon. It was stated that from 15,000 to 20,000 bushels of the seeds could probably be marketed in Ceylon each year, once its value became known to the villagers.

No. 1. This sample, labelled "Mee seed," was in poor condition, the kernels being moist and mostly mouldy. The seeds consisted of 30 per cent. shell and 70 per cent. kernel. The yield of oil was about 39 per cent. from the moist kernels, which contained about 24 per cent. of moisture. After exposure to the air for about a day the kernels contained only 6 to 7 per cent. of moisture and 47 to 48 per cent. of oil, which is a lower percentage than that found for *Bassia longifolia* kernels from India.

The fat was solid and yellowish in colour, having the usual appearance and properties of the fat derived from *Bassia longifolia* kernels. It was not submitted to chemical examination.

No. 2. The sample, labelled "Mee seed, *Bassia longifolia*," was in bad condition, many of the kernels showing signs of decay. Kernels in good condition picked from the sample yielded 54·2 per cent. of fat, which is normal for kernels of this species. The character of the fat was also normal.

No. 3. This sample, labelled "Mee kernels," was in rather bad condition; many of the kernels had been attacked by insects and a quantity of dust and debris was present.

The yield of oil from the kernels was 50·3 per cent., which is somewhat below that given by Indian kernels derived from this species. The character of the fat was normal.

No. 4. "Mee oil from R. M. Udaisambera Urugela." It consisted of clean, granular fat of pale greenish-yellow colour.

No. 5. "Jaffna Illupai (Mee) oil." It was clean, semi-solid, pale yellowish-white fat.

The following table gives the results of examination of the two samples of fat as received from Ceylon:—

	No. 4.	No. 5.
Specific gravity at $\frac{100^\circ \text{ C.}}{15·5^\circ \text{ C.}}$ ...	0·861	0·861
Acid value ...	25·7	5·8
Saponification value ...	191·5	191·5
Iodine value ...	61·2	57·6
Titer test ...	40·2° C.	41° to 42° C.

On comparing the above results it will be seen that there is a considerable difference in the amounts of fat present in the three kinds of kernels, *B. butyracea* being richest, and *B. latifolia* the least rich in this respect. Recent analyses by Menon (*loc. cit.*) of Indian kernels from these three species gave results very similar to those now recorded, and confirm the view that the kernels of *B. latifolia* contain less fat than those of *B. longifolia*, and the latter, in turn, less than those of *B. butyracea*.

As regards the fats from these three kinds of kernels there is very little to choose between those furnished by *Bassia longifolia* and *B. latifolia*, but the fat from the kernels of *B. butyracea* is harder and whiter than those from the other two species, and should be more valuable commercially. It is understood that whilst *Bassia longifolia* and *B. latifolia* kernels are exported from India in large quantities, there is at present practically no export of *Bassia butyracea* kernels, apparently because all that are available are used locally for the production of edible fat.

Watt (*Commercial Products of India*, 1908, p. 120) mentions that the kernels of *Bassia butyracea* are regarded in India as yielding a more valuable fat than ordinary Mowra kernels, and the results now recorded confirm that view. It would seem to be desirable to encourage the export of *Bassia butyracea* kernels from India if enough are available for that purpose, and it would be well, in view of their richness in fat and the superior quality of this fat, that they should be marketed under a distinct name, so that they will not be sold in Europe as Mowra or Illipi kernels.

At present Bassia kernels are more popular with oil-seed crushers in Germany and France than in the United Kingdom. One reason for this appears to be that the cake left after expressing the fat is considered poisonous to cattle, owing to the saponin it contains, and consequently only fetches low prices, being used as a manure instead of as a feeding-stuff. Investigations recently carried out at Liverpool (*Bio-Chemical Journal*, February, 1910, p. 93) have shown that oil-cake made from the kernels of *Bassia longifolia* contains a saponin-like glucoside, which has a marked physiological action when injected subcutaneously, but does not appear to be very active when fed to animals. Careful feeding trials on a considerable scale with oil-cakes made from Bassia kernels would, however, have to be made before it would be safe to say whether or not such materials could be used as feeding-stuffs for cattle, and, even if they proved harmless, it is probable that their intensely bitter taste would preclude their use in this way.

The value of Mowra kernels is about £11 per ton (May, 1911). This price appears to be paid for kernels containing about 46 per cent. of fat, and it is clear that kernels in good condition and containing 54 or more per cent. of fat, such as the *B. longifolia* kernels from India and Ceylon, should bring somewhat higher prices under present conditions.

"KATIAU" SEEDS AND FAT FROM BRITISH NORTH BORNEO.

Within recent years considerable quantities of oil-seeds have been exported from Sarawak under the name of "Illipé" seeds. These are derived from species of Shorea and Isoptera, belonging to the Dipterocarpaceæ, and must therefore be distinguished from the "Illipé" seeds of India, which are derived from Bassia spp. (see above). A true Bassia, known as "katiau," "katio," or "kachiau," however, does occur in Borneo, the fruits of which are much sought after by the natives, who use the fat contained in the seeds for cooking and other food purposes.

Samples of "katiau" seeds, and of fat prepared from them, were received from British North Borneo in September 1909, and the results of their examination are given below.

Herbarium specimens of the "katiau" plant, subsequently forwarded to the Imperial Institute, have been identified at Kew as a form of *Bassia Mottleyana*, C. B. Clarke (Sapotaceæ).

"Katiau" Seeds.—The sample consisted of brown, shiny seeds, measuring about $\frac{3}{4}$ in. by $\frac{3}{8}$ in., and resembling other small Bassia seeds in general appearance. The shells were thin and easily broken; the kernels were brownish, and in many cases covered with a black fungus. The seeds consisted of kernel, 68 per cent.; shell, 32 per cent. The average weight of a single seed was 0·34 gram.

The kernels yielded 51·3 per cent. of pale greenish-yellow solid fat, of soft consistence, equivalent to a yield of about 35 per cent. from the whole seed.

"Katiau" Fat.—This consisted of a yellow, pasty fat, having a strong smell of benzaldehyde (oil of almonds). It was at first

considered possible that the presence of benzaldehyde in this oil might have been caused by the action of an enzyme on a glucoside existing in the seed. If such were the case, however, the aldehyde would probably have been accompanied by prussic acid; whereas, although benzaldehyde was proved to be present in the oil, no prussic acid could be found. Moreover, no prussic acid or benzaldehyde could be detected in the "katiau" seeds themselves. In view of these facts it seems certain that a small quantity of benzaldehyde had been added to the oil for the purpose of scenting or flavouring it. In this connection it is interesting to note that a sample of native-prepared "katiau" fat, examined by C. J. Brooks (*Analyst*, 1909, **34**, 207), also had a pleasant odour of almonds.

The fat extracted from the seeds at the Imperial Institute and that sent from Borneo were examined with the following results, which agree fairly closely with those obtained by C. J. Brooks for the sample of native-prepared fat referred to above:

	Fat extracted from seeds at the Imperial Institute.	Fat sent from Borneo.
Specific gravity at $\frac{100° C.}{15·5° C.}$	0·885	0·864
Acid value	77·9	2·3
Saponification value . . .	191·0	191·5
Iodine value	65·0	65·0
Titer test	36·4° C.	36·3° C.
Hehner value		96·0
Reichert-Meissl value	0·8	0·6

The high acid value of the fat extracted at the Imperial Institute is due to the fact that the seeds were old, and had become somewhat mouldy, with the result that the fat had decomposed to some extent. The specimen prepared in Borneo was doubtless obtained from fresh seeds.

The fat extracted at the Imperial Institute was found to consist principally of the glycerides of oleic and stearic acids, and probably also of palmitic acid. These glycerides appear to be present approximately in the proportions of olein, 75 per cent.; stearin (and probably palmitin), 25 per cent.

The fat closely resembles that of *B. latifolia*, but is somewhat softer. The kernels contain about the same proportion of fat as Indian "mowra" kernels, and would probably realise approximately the same price as the latter. This price was about £11 per ton in the United Kingdom in May 1911.

"Katiau" fat would find application in the manufacture of soap and candles, and possibly in the preparation of edible fats.

"MINYAK SURIN."

FEDERATED MALAY STATES.

The Imperial Institute received in 1904 an enquiry from a firm of soap-makers in the United Kingdom asking for information as to the possibility of obtaining commercial supplies of the seeds of *Palaquium* (*Dichopsis*) *oblongifolium*, Burck, (N.O. Sapotaceæ), or the oil expressed from these seeds.

In dealing with this enquiry it was found that practically nothing was known about these materials in this country, and that the information available regarding them in English and foreign literature is apparently entirely derived from a statement made by Dr. Burck (*Mededeelingen uit 's Lands Plantentuin*, III., p. 40), that the seeds yield a hard, white fat known as "Njatoh" fat, chiefly composed of stearin and olein, and which would be suitable for the manufacture of stearin candles.

It was considered unlikely that this product would prove to be of commercial interest since it is well known that this species of Palaquium only occasionally furnishes seeds, and that consequently large supplies of the seed were not likely to be obtainable, but in view of Burck's statement as to the composition of the fat and the uses to which it could be applied it appeared to be worth while to obtain a sample of the material for examination. Application was therefore made to the Superintendent of the Botanic Gardens, Singapore, and to the Director of Museums at Perak, Federated Malay States, for samples of the seeds or the expressed oil, and for any information which might be available locally regarding either of these products.

In response to this request the Superintendent of the Botanic Gardens, Singapore, in a letter dated the 6th December, 1904, stated that the seeds of *Palaquium oblongifolium* were extremely rare; that on some occasions as much as a dollar for each seed had been offered without securing any supplies, and that although during the last few years small quantities of the seeds had become available in the Straits Settlements, it was improbable that any had been used for the extraction of fat.

Similarly the Director of Museums at Perak, in a letter dated the 16th December, 1904, said that he could hold out no hopes of being able to obtain either the fat or the seeds of *Palaquium oblongifolium*, as seeding trees of this species are rare, but the fat known to the Malays as "Minyak Surin," obtained from the seeds of a tree allied to *Palaquium oblongifolium*, could be secured in small quantities, and that he would send a sample of this material for examination.

The following information was given regarding Minyak Surin:—

> "The Surin trees grow singly in the jungle, usually at wide intervals, so that the collection of the seed is a matter of difficulty. The Malays on finding a tree shedding its seeds, gather them up and after husking and sun-drying them, express the fat by means of a wedge-press called 'Apit Surin.' The fat does not come into the local market, but is used by the makers for cooking purposes. The fat could not be obtained in quantities at a price which would make it available for either soap- or candle-making."

The botanical name of the Surin tree was not supplied.

The sample of "Minyak Surin" received weighed about two pounds, and consisted of cylindrical pieces of solid fat, which contained much dirt and foreign matter. The fat had a peculiar odour but was not rancid.

A portion of the sample was sent to Dr. J. Lewkowitsch, who had offered to investigate this material, and he was good enough to supply to the Imperial Institute the following observations with regard to it:

"The fat was very dirty and was filtered to remove insoluble impurities. The chemical examination gave the following results:—

Saponification value		179·5
Unsaponifiable matter		4·54
Free fatty acids	per cent.	43·2
Iodine value		42·31
Reichert-Meissl value		0·55

"The mixed fatty acids were isolated from a portion of the fat and gave the following results:—

Solidifying point of mixed fatty acids		59·10° C.
Mean molecular weight of fatty acids		284·9
Proportion of stearic acid (m.p. 67·8° C.) in total fatty acids	per cent.	58·2

"From the foregoing numbers the conclusion may reasonably be drawn that the fatty acids consist practically entirely of stearic and oleic acids, but a more thorough investigation would be necessary before this could be asserted definitely.

"The high proportion of stearic acid would render this fat a most useful raw material for the candle industry were it not for the presence of considerable amounts of unsaponifiable matter, which would be equally objectionable in soap manufacture. The commercial value of the fat would probably be from £24 to £26 per ton" (July, 1905).

It was pointed out in the letter accompanying this sample that owing to the sparse distribution of the Surin trees in the Federated Malay States this material could not be of any commercial importance since no large supplies of the seeds could be obtained, but it is interesting to note that the fat is suitable for industrial use and that it would probably sell at fairly high prices if it could be obtained in large quantities.

The observation that "Minyak Surin" consists of stearin and olein is also interesting as showing that its composition is similar to that ascribed by Burck to the fat obtained from the seeds of *Palaquium oblongifolium*, and in this connection it would be of some interest to know the botanical name of the Surin tree, in order that its exact botanical relationship to *Palaquium oblongifolium* might be ascertained.

DIKA NUTS (*Irvingia Barteri*).

SOUTHERN NIGERIA.

Samples of unshelled "dika nuts," of the so-called "dika" or "Gaboon chocolate," and of the sun-dried kernels of the nuts, were forwarded to the Imperial Institute for examination by H.M. Commissioner for Southern Nigeria in August, 1904.

"Dika" or "Gaboon Chocolate."—The sample consisted of a single round cake about 6 inches in diameter. It was of a dirty brown colour externally and was brownish-white internally. It was friable and possessed a mouldy odour, which was masked to some extent by the aroma of the pepper which had been incorporated with the material in preparing the cake.

This sample was compared with a specimen of "dika chocolate" supplied by the Director of the Royal Botanic Gardens, Kew. The Kew sample was similar to that sent from Southern Nigeria, but was somewhat harder, and internally was much darker in colour. It possessed also a curious aromatic odour quite distinct from that of the specimen from Southern Nigeria. The Kew sample appeared to have been cut from a circular cake about 6 inches in diameter. This so-called "dika chocolate" consists of the ground fresh kernels of the nuts, from which a portion of the fat has been removed, worked up into cakes with pepper and salt. The "chocolate" is a staple article of food among West African natives.

Undecorticated "Dika Nuts."—The supply of undecorticated nuts weighed about 50 lb. On examination it was found that only about 5 per cent. of the nuts were sound. This material was therefore unsuitable for detailed investigation.

Sun-dried Kernels.—About 3 lb. of this material were received. The kernels were prepared by cracking the nuts and drying the kernels in the sun. On cracking the nut the kernel splits into two halves, and this sample consisted almost entirely of such split kernels. The material was in good condition when received, and a portion of the sample which had been retained for reference showed no sign of decomposition after preservation for over a year. It is evident, therefore, that the sun-dried kernels, when carefully prepared, may be kept for some considerable time without undergoing decomposition.

Portions of the sample of "dika nuts" and of the kernels were submitted to an expert, and the following observations on these materials have been kindly supplied by him to the Imperial Institute:—

"The 'dika nuts' were examined immediately on arrival. The kernels in these were, however, found in so advanced a state of mouldiness that it was considered useless to extract any fat from them. The sound nuts yielded 20 per cent. of kernels. The sun-dried kernels were in a comparatively fresh condition; they contained 54·3 per cent. of fat. This fat, on examination, gave results indicating that it consisted principally of glyceryl esters of fatty acids less complex than stearic acid, the preponderating constituent being apparently lauric acid."

A more detailed account of the chemistry of the fat contained in "dika nuts" is given in a paper by Dr. J. Lewkowitsch, who worked with material supplied by the Imperial Institute (*Analyst*, 1905, **30**, 394)

The foregoing results indicate that the "dika fat" expressed from the sun-dried kernels would be suitable either for soap or candle manufacture, and for these purposes it would be worth from £25 to £27 per ton, and the "dika kernels" probably from

£10 to £12 per ton (August, 1905). It would not be advisable to ship the unshelled "dika nuts" from Southern Nigeria to this country, since the cost of transport would thereby be materially increased, and the cost of decortication in this country would be high, so that it is unlikely that the unshelled nuts could be sold here at a remunerative price.

Several other samples of the nuts and kernels from Southern Nigeria have been received, and the results of examination of these are given below. The proportion, by weight, of kernels in the nuts varied from 18 to 20 per cent.

—	Sample No. 1.*	Sample No. 2.	Sample No. 3.
Yield of fat (on kernels), per cent....	54·3	60·1	66·3
Specific gravity at 100°/15°C. ...	—	0·863	—
Acid value	6·6	12·6	1·8
Saponification value	241·5	250·0	243·8
Iodine value	5·2	3·3	4·2
Unsaponifiable matter	0·7	—	—
Titer test	34·8°C.	—	—
Melting-point of fat	—	—	39·2°C.

* This sample was examined by Dr. Lewkowitsch (*Analyst*, 1905, **30**, 394).

MAFOUREIRA SEEDS.

(*Trichilia emetica.*)

PORTUGUESE EAST AFRICA.

The consignment of these nuts now dealt with came from Portuguese East Africa.

It consisted of ovoid fruits, about ¾ inch long and ½ inch broad, composed of a chocolate-brown shell, more or less covered with a reddish oily pulp, enclosing a single dull greyish-brown kernel, which readily splits into two parts. The kernels break with a granular fracture and readily yield oil under the pressure of the finger-nail.

The nuts were sent to a manufacturing firm for technical examination. The kernels yielded 54·46 per cent. of fat, and the husks 50·37 per cent.

The fats obtained from both the husks and kernels were solid and of dirty-green colour; they could not be bleached by any of the ordinary processes used in bleaching fat for soap manufacture.

	Fat from kernels.	Fat from husks.
Acid value	36·7	17·7
Saponification value	200·3	209·7
Iodine value	52·6	71·6
Titer test...	53·2° C.	45·4° C.
Unsaponifiable matter... ...	1·4	1·3

The fat obtained by expression from the seeds has also been examined by Daniel and McCrae (*Analyst*, 1908, **33**, 276), who found the following values: saponification value, 201; iodine value, 43·5; unsaponifiable matter, 1·2.

In reporting the results of the commercial trial, the firm stated that the dark colour of the fat would render it unsuitable for making the better qualities of soap, and that, in consequence, it would only realise the price of "soft, off-coloured tallow" for soap-making purposes.

The cake left after the extraction of the fat in these experiments contained a larger quantity of fat (25·8 per cent.) than would probably be left in the cake when working on the commercial scale. The yield of fat obtained from the nuts in actual manufacturing operations would therefore probably be larger than the figures recorded above. A chemical examination showed that the cake contained 3·49 per cent. of nitrogen, equivalent to 4·4 per cent of ammonia, and the equivalent of 1·5 per cent. of phosphoric anhydride.

These results show that the nuts furnish a satisfactory yield of solid fat, which is, unfortunately, of rather dark colour; and information received from other manufacturers who have tried this material as a source of fat, confirms the view that it is difficult to bleach. The cake left after the removal of the fat is unsuitable for use as a feeding material, since it is very bitter and probably possesses emetic properties.

A second supply of Mafoureira seeds was received at the Imperial Institute from the Companhia de Moçambique, in April, 1910.

This consignment was obtained in order that further technical trials might be carried out with the seed, oil, and residual cake.

The consignment weighed about 10 cwt., and was composed of seeds rather over ½ inch long and ⅓ inch wide, which had brown papery husks and greyish-brown oily kernels. Each seed was partly covered with red oily pulp.

The bulk of the consignment was forwarded to a large firm of oil-seed crushers in order that the fat might be expressed and submitted to technical trials and that an examination might be made of the residual cake. The firm reported that the ordinary crushing machinery was not very suitable for dealing with these seeds, but that this would not be any objection if they are available in quantity, as special arrangements could easily be made.

Fat.—The entire seeds were found to contain 56·6 per cent. of fat, as compared with 56·3 and 54·2 per cent. in the case of two samples from Nyasaland (see p. 559).

The fat expressed from the seeds was a buff-coloured, solid, hard, and rather granular material. It furnished the following results on examination:—

	Fat from entire seed.
Specific gravity at 100°/15·5° C.	0·866
Acid value	19·0
Saponification value	205·4
Iodine value	50·0
Titer test	49·2° C.

The oil-seed crushers were of opinion that the fat would be suitable for the manufacture of soap, as it saponifies readily and yields a soap of good colour, most of the colouring matter of the fat remaining in the lye. They accordingly submitted it for practical trial to a large soap-making firm, who reported that it was very satisfactory for this purpose, and that as it is a hard fat it should always find a ready sale among soap manufacturers. They considered that Mafoureira fat would compete favourably with Chinese vegetable tallow.

Another large firm of soap-makers who were consulted by the Imperial Institute reported that the colour of the fat would render it unsuitable for the production of first-class soaps.

Cake.—The residual cake obtained in the crushing trial was a light, brown, soft, friable material with a very bitter taste. It contained 28·6 per cent. of fat, which is a much higher proportion than would be left in the cake when working with suitable machinery on a commercial scale. Trials showed that the cake could not be utilised as a feeding-stuff. It was found impossible to induce sheep to eat it, even when mixed with other rations, evidently on account of the intensely bitter taste.

The cake contains very little nitrogen and phosphoric acid, and is not likely to be of much value as a manure (see p. 557), but further experiments on the subject are in progress.

The firm of oil-seed crushers considered that the fat expressed from Mafoureira seeds would be worth about £30 per ton in the United Kingdom (January, 1911), and that the value of the seeds, based on the above value of the fat and on the value of the cake as manure, would be £10 to £11 per ton in the United Kingdom. The firm added that a better market might possibly be found for the cake and that if so, the value of the seeds would be correspondingly increased.

The price of £10 to £11 per ton quoted above for Mafoureira seeds was higher than an offer of £9 5*s*. per ton which was made by a firm of London brokers in 1906 for a consignment of this seed. This increase in value was due to the fact that all oil-seeds had risen considerably in price in the interval.

It is clear that a good market should be found for Mafoureira seeds in the United Kingdom if they can be shipped regularly in commercial quantities, and in good condition.

It has been stated recently that a smaller variety of Mafoureira seeds has appeared on the market, which invariably contain a much smaller proportion of fat than the large variety, *e.g.*, 26 to 34 per cent., against over 50 per cent. in the samples of the large seeds examined at the Imperial Institute. It is, of course, important that these small seeds should not be mixed with the large seeds for export.

NYASALAND.

In Nyasaland the nuts of *Trichalia emetica* are known by the native name "Msichitsi." Those which are the subject of this Report were forwarded to the Imperial Institute by the Chief Forest Officer at Zomba in March, 1909.

Two samples, collected at different elevations, were forwarded and it was desired to know whether there was any variation in the amount of oil present.

1. "Msichitsi nuts (*Trichilia emetica*) from Karonga district, grown at an altitude of about 1,250 feet."

These nuts had the usual appearance of the seeds of *Trichilia emetica* (Mafoureira nuts). The husks were thin, and easy to detach.

2. "Msichitsi nuts from Zomba, grown at an elevation of about 2,900 feet above sea level."

These nuts were like those of sample No. 1, but the husks were thicker and softer, and not so easily removed from the kernel as in the previous case. The sample was dusty, and otherwise less clean than sample No. 1.

The composition of the two samples was as follows:—

	No. 1. Per cent.	No. 2. Per cent.
Kernel	75	65
Husk	25	35

The percentage of fat in the two samples was determined with the following results:—

Fat from	No. 1.		No. 2.	
	Yield per cent.	Description of fat.	Yield per cent.	Description of fat.
Whole seeds ...	56·3	Buff-coloured, solid ...	54·2	Brown, solid.
Husks	42·9	Pale yellow, semi solid	15·5	Brown, semi solid.
Kernels ...	61·3	Pale brown	60·0	Pale brown, solid.

The above results show that both samples are of the usual quality. The yields of fat do not differ sufficiently to enable any conclusions to be drawn as to the effect on the yield, of the altitude at which the trees are grown. The proportions of fat in commercial samples of Mafoureira nuts show a much greater variation.

LOPHIRA ALATA SEED AND OIL.

SIERRA LEONE.

Supplies of the seeds and fruits of this tree, which is widely distributed in Sierra Leone, and, indeed, throughout the coastal districts of West Africa, were received in June, 1907, at the Imperial Institute from Sierra Leone for examination as an oil-seed, it being thought that the product would be likely to be of some commercial importance since the seeds are obtainable in large quantities in readily accessible areas. The tree is already well known as one of the sources of the so-called African oak, whilst the oil prepared from the seeds is known in Sierra Leone as "Niam" fat or "Meni" oil.

In all, five samples of the seeds and fruits have been received for examination from Sierra Leone.

Fruits.—These were roughly conical and each consisted of a reddish-brown, fibrous shell, usually about $\frac{1}{32}$ inch thick, enclosing a single seed or kernel. The fruits consisted of about

40 per cent. husk and 60 per cent. kernel. In many of the fruits received the kernels had undergone partial decomposition, and were dark brown, instead of almost white, internally.

Kernels.—These were conical in shape about ⅝ inch in length, and ¼ inch broad at the base. Externally they varied in colour from orange-brown to, in a few cases, greenish-black. Internally they were almost white or pale yellowish in colour when fresh, but tended to become brown when kept, and this darkening in colour seemed as a rule to begin at the apex. They contained a semi-solid yellowish-white fat, and the amount of this present varied in the samples examined from 31·1 to 43·0 per cent., the variation being due apparently to three causes: viz., differences in (1) the maturity of the fruits when collected; (2) in their condition, as regards freshness, and (3) in dryness of the kernels examined.

Characters of the Fat.

Small quantities of the almost white or pale yellow semi-solid fat present in the kernels were prepared from each of the products received, and these were chemically examined. The results obtained are given in the following tables:—

Table I.

Yield of Fat.

	A.	B	C	D	E
Product received	Fruits.	Kernels	Fruits	Kernels.	Kernels
Condition of kernels ...	Mostly sound.	Good.	Many partly decomposed.	Good.	Fairly good
Yield of fat (per cent. calculated on the weight of kernels used).	31·19	43·0	39·6	41·16	41·76

Table II.

Constants of Fat.

	A.	B.	C.	D.	E
Specific gravity 40°/40° C.	0·9105	0·9044	0·9044	0·9019	0·9016
Acid value	18·54	25·9	33·2	47·5	48·0
Saponification value ...	195·6	181·5	194·6	180·7	183·3
Iodine value	68·4	69·8	70·3	72·1	72·5
Reichert-Meissl value ...	—	0·9	0·9	0·8	0·8
Unsaponifiable matter ...	1·49	0·5	—	—	0·86
Titer test	—	49·0° C.	47·0° C.	47·5° C.	48·5 C

It will be noticed that the decorticated kernels are somewhat richer in oil than those which were exported in an undecorticated state, for the reasons already given. In the case of the last two samples of decorticated kernels, the oils prepared from them are more rancid, as indicated by the higher acid values, than those obtained from the kernels exported in the shell, but the difference is not marked, and scarcely affects the commercial value of the oil. It is curious that the oils from the decorticated kernels have uniformly lower saponification values than the oils from the undecorticated kernels, but this difference is probably of little importance.

It is clear from these results that it will be advantageous to export the kernels in a decorticated state to save freight and the cost of decortication in Europe, and that so long as the decorticated kernels are thoroughly dried before export there is no likelihood that they will reach Europe in an unsatisfactory condition. Further, the results of the examination of sample E, which was stored in the Colony during two months of the rainy season before shipment to this country, indicate that the kernels do not deteriorate much as the result of storage in a moist atmosphere. A portion of the consignment B was submitted to a firm of soap manufacturers in order that the oil might be expressed on a small commercial scale and tried for soap-making. This firm reported that the decorticated seeds yielded 43·4 per cent. of oil, which for their purposes would be worth from £1 to £2 per ton more than cotton-seed oil under ordinary market conditions.

A small sample of the kernels was also submitted to a firm of oil-seed crushers, who confirmed the above valuation of the oil, and valued the kernels provisionally at £10 per ton, c.i.f., Liverpool, June, 1908. It remains to be seen whether this price will, after paying for the collection of the fruits and their decortication in Sierra Leone, leave a margin large enough to induce traders to ship this product.

A large consignment of the kernels was received subsequently from Sierra Leone in September, 1910. They had been obtained from fruit collected in the Karene district of the Protectorate.

The consignment, which consisted of 112 bags, each containing two bushels of kernels, was forwarded to a large firm of oil-seed crushers in Liverpool, who had undertaken to carry out technical trials with the material.

The oil-seed crushers reported that the kernels contained about 40 per cent. of fat, which agrees with the figures obtained for the previous samples from Sierra Leone examined at the Imperial Institute (see above). After a number of trials to determine the best method of extracting the fat on a commercial scale, the kernels were crushed, and samples of the fat and of the residual cake were supplied to the Imperial Institute for detailed investigation.

(1) *Fat.*—The sample consisted of a clean, pale buff-coloured solid fat, having a slight, but not unpleasant, odour and taste. It was examined with the following results, compared with those recorded for previous samples of *L. alata* fat :—

	Present sample.	Previous samples examined at the Imperial Institute.
Specific gravity at $\frac{100^\circ \text{ C.}}{15^\circ \text{ C.}}$	0·859	—
,, ,, $\frac{40^\circ \text{ C.}}{40^\circ \text{ C.}}$	—	0·9016 to 0·9041
Acid value	26·0	25·9 ,, 48·0
Saponification value ...	188·9	180·7 ,, 183·3
Iodine value	68·0	69·8 ,, 72·5
Titer test	45° C.	47·5° ,, 49° C.
Unsaponifiable matter ...	2·5 (approx.)	0·5 ,, 0·86

The present sample of fat, therefore, resembles the specimens extracted at the Imperial Institute in 1908 (see p. 560).

For a detailed account of the chemistry of this fat, see "The Composition of the Fat from the seeds of *Lophira alata*," by Messrs. Pickles and Hayworth (*Analyst*, 1911, **36**, 493).

(2) *Cake*.—This material was forwarded to the Imperial Institute in the form of rectangular cakes, of chocolate-brown colour, and presenting a mottled appearance internally when broken. The taste was bitter and strongly astringent, indicating that the material would be unsuitable for feeding purposes and could only be utilised as a manure.

The cake was analysed with the following results, expressed on the material as received:—

	Per cent.
Moisture	8·50
Ash	4·48
Nitrogen	1·87

The ash contained:—

		Per cent.*
Potash	K_2O ...	1·91
Lime	CaO ...	0·18
Magnesia	MgO ...	0·30
Phosphoric acid	P_2O_5 ...	0·51

These results indicate that *L. alata* cake is suitable for use as a manure, but is of rather lower value for the purpose than castor-seed cake, rape-seed cake, cotton-seed cake, and similar materials.

Commercial Valuation.

(1) *Fat*.—*L. alata* fat is suitable for soap-making, and the firm of oil-seed crushers who expressed the present sample ascertained that its value for the purpose would be about the same as that of palm oil, viz., about £30 to £31 per ton in Liverpool (November, 1911).

The fat was submitted to two firms with a view to ascertaining its suitability for edible purposes, but in both cases the report was unfavourable owing to the taste and the high acid value of the material. The oil-seed crushers also considered that the cost of sufficiently refining the fat would preclude its use in this way

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* Expressed on the cake.

(2) *Cake.*—The oil-seed crushers stated that this material closely resembles shea-nut cake, and they considered that it would have a similar value, viz., about £3 per ton in Liverpool (November, 1911). This value is rather above the average; the price fluctuates between this and 45*s*. per ton.

(3) *Decorticated seed.*—The oil-seed crushers reported that the decorticated seed (kernels) with which they carried out the experiments contained about 40 per cent. of oil, and on this basis they valued the kernels at about £10 per ton c.i.f. Liverpool (October, 1911).

It is clear from the foregoing results that the decorticated kernels of *L. alata* should find a ready market in Europe as a source of oil for soap-making, and that the cake left after expression of the fat could be utilised as a manure.

SUDAN

A sample of oil prepared in the Sudan from the seeds of *Lophira alata* has also been received for examination. The product is known in the Sudan as "Zawa" oil.

The sample consisted of a dark orange-brown oil, containing a little sediment. The chemical examination of the oil gave the following results, for comparison with which the figures obtained in the laboratories of the Gordon College, Khartoum, for another sample of Zawa oil, are added:—

	Sudan sample sent to Imperial Institute.*	Sudan sample examined at Gordon College Laboratories.
Specific gravity at 40° 40° C.	0 9063	0 8615†
Acid value	5·78	—
Saponification value	190·10	177·1
Unsaponifiable matter.. ...	1·38	—
Iodine value	78·12	72·7
Titer test	42·5° C.	—

The oils extracted from the Sierra Leone seeds at the Imperial Institute were almost white or pale yellow and semi-solid, whereas the oil received from the Sudan was much darker in colour and liquid, though it deposited a good deal of solid matter on standing.

The Sudan oil had an unpleasant taste, but Dr. Beam of the Gordon College laboratories records that the oil he examined had an agreeable flavour, somewhat recalling that of arachis oil. All the oils prepared at the Imperial Institute from seeds received from Sierra Leone had a slight unpleasant taste, and the residual cake was bitter.

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* The Sudan sample was examined for the Imperial Institute by Dr. Lewkowitsch, and is described in the *Journ. Soc. Chemical Ind.* (1907. **26**, 1265).

† Specific gravity at 100°/15° C.

LOPHIRA PROCERA SEEDS.

Gold Coast.

A sample of "Kaku" seeds (*L. procera*) collected at the Agricultural Station, Tarquah, Gold Coast Colony, was received for examination at the Imperial Institute in April, 1911.

The seeds were roughly conical, each containing a single kernel. The shells were reddish-brown, thin, fibrous, and easily broken; the kernels were soft, and white to brown in colour internally.

The seeds consisted of shell, 25 per cent.; kernel, 75 per cent The average weight of a single seed was about 0·83 gram, and of a kernel about 0·62 gram.

The kernels yielded 55·3 per cent. of cream-coloured, solid fat, and they contained 8·7 per cent. of moisture.

The fat was examined chemically, with the following results:—

Specific gravity at $\frac{100^\circ \text{ C.}}{15{\cdot}5^\circ \text{ C.}}$	0·859
Acid value	11·6
Saponification value . ..	190
Iodine value	60
Unsaponifiable matter	0·8

The kernels of these seeds of *L. procera* yield a larger percentage of fat than those of *L. alata*, but the fat from both kinds of seed is of a similar character.

A sample of the *L. procera* kernels was submitted to a large firm of oil-seed crushers for technical trials. They reported that the fat would be suitable for soap-making. The residual cake has a bitter taste, and would consequently be of no value as a feeding-stuff; it could be used as a manure, but as it contains only 3½ per cent. of ammonia, it would not be worth more than about 35*s*. per ton for this purpose.

On the above basis, the firm valued the decorticated kernels of *L. procera* at about £12 per ton delivered in Liverpool (February, 1912).

CARAPA SEEDS.

Oil-seeds from several species of Carapa have been received at the Imperial Institute for examination. As there appears to be a good deal of confusion in the technical literature regarding the botanical origin of the various Carapa seeds and oils which have appeared in commerce from time to time or have been investigated by chemists, it will be convenient to summarise here the distribution of the various oil-seed yielding Carapa species and their synonymy. For the latter purpose, De Candolle's monograph on the order Meliaceæ, in which the genus is placed, is taken as the authority.

Carapa procera, DC.—*C. Touloucouna*, Guill. et Perr.; *C. guineensis*, Juss.; *C. guyanensis*, Oliv. This occurs in the Antilles, Guiana, Senegambia and tropical Africa.

Carapa guianensis, Aubl.—that of Oliver's Flora of Tropical Africa, *pro parte*. This is found in Guiana, Martinique, San Domingo, Guadeloupe, Venezuela and Brazil.

Carapa moluccensis, Lam. Occurs in East Africa, Seychelles, etc.

Carapa grandiflora, Dawe and Sprague. Occurs in East Africa and Uganda.

SIERRA LEONE.

This consignment described as *Carapa guyanensis* (*C. procera*, *DC.*) consisted of characteristic roughly tetrahedral seeds, each having a rather rough reddish-brown shell enclosing a single kernel covered with a pale brown papery skin. When fresh the kernels appear to nearly fill the shells, but in this consignment most of them had dried and shrunk, assuming irregular shapes. The consignment contained about 35 per cent. good kernels, 27 per cent. bad kernels, and 37 per cent. shell.

The good kernels yielded about 57 per cent. of oil by extraction with solvents, and 46·7 per cent by expression, 24 per cent. being obtained in the cold and 22 per cent. on heating and further expression.

The "cold pressed" and "hot pressed" oils presented much the same appearance, being viscous dirty-brown liquids, and possessing a slight, characteristic odour, and extremely bitter taste.

	Cold pressed oil.	Hot pressed oil.
Specific gravity at 40°C.	0·9179	0·9174
,, ,, 15°C.	0·9272	0·9327
Saponification value	197·1	196·4
Iodine value	75·6	71·2
Reichert-Meissl value	3·5	3·1
Unsaponifiable matter	1·5	2·0
Titer test	35·1°C.	36·1°C.

A portion of the "hot pressed cake" obtained in the technical trials referred to above was analysed, and gave the following results:—

	Per cent.
Moisture	9·8
Ash	5·9
Nitrogen	2·9

The ash contained:—		Per cent.[1]
Potash	K_2O	1·91
Lime	CaO	0·18
Phosphoric anhydride ...	P_2O_5	0·51

These results indicate that the Carapa cake would be of rather low manurial value as compared with castor-seed cake, rape-seed cake, cotton-seed cake, and similar materials used as manures and would perhaps be worth about £2 per ton.

A further consignment of about 2¾ cwt. of *Carapa procera* kernels from Sierra Leone was received at the Imperial Institute in June, 1909, and as these were similar to those previously received, they were not chemically examined, but were forwarded to a firm of oil-seed crushers who extracted the oil and submitted it to soap and candle manufacturers in the United Kingdom for trial. As a result, it was found that the oil would be suitable for these purposes and on the basis of these trials the firm of oil-seed crushers agreed to take a trial consignment of 50 tons of kernels for which they would be willing to pay £11 5*s.* per ton for "dark kernels" and £11 10*s.* per ton for "light kernels" (November, 1909).

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[1] Calculated on the cake.

The price offered is somewhat higher than that estimated for the previous samples. This is in part due to the better condition of the present consignment, but chiefly due to the considerable rise in price of fats and oils since the previous samples were reported on.

Gold Coast.

A supply of seeds from this Colony, referred to *Carapa guineensis* (*C. procera*, DC.) was received early in 1907. They were irregularly tetrahedral in shape and had a brittle husk, which could be easily separated. The kernels were white and spongy, and had an intensely bitter taste. The husks constituted 25·7 per cent. by weight of the seeds. The yield of oil was 19·3 per cent. from the kernels, equivalent to 36·6 per cent. on the whole seeds.

The oil was pale yellow and had a bitter taste; on standing, it partially solidified to a white mass. It is not readily extracted from the seeds by light petroleum. The oil had the following constants:—

Specific gravity … …	0·917
Acid value …	5·1
Saponification value …	196·9
Iodine value … … … …	65·7
Hehner value … … … …	93·1
Titer test … … … …	36·0° C.

Uganda.

This consisted of the seeds of *C. grandiflora* and was forwarded from Entebbe in September, 1907.

The nuts were larger than those of *C. procera*, but resembled them in shape and appearance. The kernels were moist, soft and fleshy, and consequently contained much less oil than those of an earlier sample from Uganda, which were dry and shrivelled. A fair proportion of the kernels was bad, and these were not used in the investigation.

On extraction with solvents the kernels furnished 30·2 per cent. of oil, compared with 52 per cent. from the dry kernels of a previous consignment. The kernels were also submitted to technical trials, and it was found that on cold expression, using a pressure of 150 atmospheres, they furnished 10 per cent. of a pale yellow oil, which deposited a small amount of solid matter on standing. On further expression, at a temperature of 150° F., a quantity of darker coloured semi-solid oil was obtained. Both oils were intensely bitter.

The chemical examination gave the following results:—

	Cold pressed oil.	Hot pressed oil.
Specific gravity	0·9261	0·9306
Saponification value ...	198·1	201·8
Iodine value	83·7	72·6
Unsaponifiable matter ...	3·75	1·59
Titer test	34·9° C.	38·9° C.

The residual cake was very bitter, and only suitable for use as manure. It contained the following percentages of constituents of manurial value: nitrogen, 2·07; potash, 1·18; phosphoric anhydride, 0·603; and lime 0·296.

Comparison of Carapa Oils.

In view of the fact that the oils now dealt with came from two different species and three different localities, it is of interest to give in one table the results obtained with them, and to add figures for a sample of oil from seeds of *Carapa guianensis*, Aubl., from Trinidad, previously examined. (See *Technical Reports*, published by the Imperial Institute, 1903, p. 135.)

Source of oil.	Country of origin.	Specific gravity.	Acid value.	Saponification value	Iodine value.	Hehner value.	Titer test.
							°C.
C. procera ...	Gold Coast...	0·917	5·4	196·9	65·7	93·1	36·0
,, ...	Sierra Leone	0·927*	—	197·1	75·6	—	35·4
		0·932†	—	196·4	71·2	—	36·1
C. grandiflora	Uganda	0·9261*	—	198·1	83·7	—	34·9
		0·9306†	—	201·8	72·6	—	38·9
C. guianensis...	Trinidad ..	0·9225	-	195·6	65·0	93·7	

* Cold pressed oil. † Hot pressed oil.

It will be seen that the oils exhibit a close general resemblance, and it would appear likely that the composition of the oils derived from the three species differs but little. It is also remarkable that the seeds of all three species are very bitter. This bitterness appears to be due to a resinous substance soluble in alcohol.

Commercial Value.

The technical expert who carried out trials with samples of Carapa seeds from Sierra Leone, Gold Coast, and Uganda, valued the oil at about £20 10s. per ton, and stated that as the residual cakes were very bitter they could not be used for feeding purposes. As the analyses given above show that these cakes are also of low manurial value it is probable they would not be worth more than £2 per ton.

PYCNANTHUS SEEDS.

Fruits, seeds and mace derived from *Pycnanthus* spp. have been received from Northern Nigeria, Sierra Leone and Uganda for examination as oil-yielding materials.

NORTHERN NIGERIA.

The fruits of a species of Pycnanthus, probably *Pycnanthus Kombo*, Warb. (N.O. Myristicaceæ), were included in a collection of products from Northern Nigeria, sent to the Imperial Institute in 1906.

The fruits were of the size of a small oval plum, and in the dry state weighed about 4 grams. They were easily broken into two thick hard pieces of husk, and an inner nut covered with a false aril, corresponding to the mace of the common nutmeg derived from *Myristica fragrans*, to which the genus Pycnanthus is nearly allied. The Pycnanthus seeds, it should be stated, are sometimes mistaken for nutmegs, though they have no aroma and are devoid of volatile oil.

The "mace" was deep brown, almost black, in colour. It possessed a slight fragrance ,and was therefore examined for essential oil, but no appreciable quantity was present.

The nuts had a very thin shell, which was easily removed from the contained kernel. The latter was white internally, with dark brown rays penetrating it from the exterior; it was easily cut and had a very bitter taste, which would preclude the possibility of utilising the "cake" left after the extraction of the fat as a cattle food. The ground kernels were extracted by light petroleum, and yielded 51 per cent of hard solid fat, of orange colour and bitter taste. It had the following constants:—

Specific gravity at 100° 15° C. .	0 886
Melting-point	48·5° C.
Saponification value	235 to 245
Acid value	24·0
Hehner value	90·8
Iodine value	48·9
Titer test	45 8° C.

The fat would probably be suitable for soap-making, though the soap made from it would be rather dark in colour. It might also be used in the manufacture of candles.

The residual meal is fairly rich in nitrogen, and might be used as a manure.

SIERRA LEONE

Samples of the fruits and the fat of *Pycnanthus Kombo*, Warb., were forwarded in March, 1911, from Sierra Leone, where the fruits are known as "Kpoye" nuts. The nuts were similar in shape to those from Northern Nigeria, but were smaller, weighing on the average 1·17 grams each. They consisted of a brittle almost black shell enclosing a single greyish-brown kernel. The latter consisted of a hard whitish substance marked by brown infoldings of the skin. The shell formed 20 per cent, and the kernel 80 per cent. of the whole nut.

The kernels contained 70·7 per cent. of solid brown fat. That extracted from the kernels at the Imperial Institute resembled the fat sent from Sierra Leone but was of a lighter colour. Both had an unpleasant odour and bitter taste.

The fat from Sierra Leone and that extracted from kernels at the Imperial Institute were examined with the following results:—

	Fat as sent.	Fat extracted from kernels at the Imperial Institute.
Specific gravity at 100°/15·5° C.	0·887	0·880
Acid value	33·0	31·4
Saponification value	231	236
Iodine value	67·6	59·0

The slight differences in the constants of the two fats are probably due to differences in the method of preparation; and both are similar to the samples of fat from the kernels of (1) *Pycnanthus Kombo* from Northern Nigeria (see p. 568), and of (2) *P Schweinfurthii* from Uganda (see, below)

The results of examination show that "Kpoye" kernels are very rich in a solid brown fat, much richer than the samples of *Pycnanthus* kernels from Northern Nigeria and Uganda.

The kernels of *P. Kombo* are probably identical with a product known as "kafu" nuts (really kernels) which have from time to time been shipped from West Africa to Liverpool and Hamburg, and which are stated to contain 73 per cent. of solid fat. Two difficulties have been experienced so far by manufacturers in dealing with these kernels, viz., that the supplies are small and irregular, and that owing to its colour the fat requires refining by a special process, which involves a considerable loss of material. This latter difficulty is probably not a serious one, in view of the fact that the Sierra Leone kernels are so rich in fat. It is, however, important, before calling the attention of manufacturers to these kernels as an oil-seed, to ascertain whether they are obtainable in Sierra Leone in large quantities and in localities so situated that the cost of transport to the coast will not be prohibitive.

UGANDA.

The material received from Uganda consisted of the nuts and mace of *Pycnanthus Schweinfurthii*, Warb.

Nuts.—These were small nut-like seeds, the shells of which were thin, fragile, dark brown and glossy, with irregular, longitudinal furrows. The kernels were small, egg-shaped, ¾ inch long and ½ inch broad at the widest end; they were brown externally, and yellowish-white internally, with isolated brown patches due to invaginations of the seed coat.

The kernels yielded to solvents 60·2 per cent. of fat, which was fairly hard at ordinary temperatures (15° C.), and was of dark brown colour; it had a slight peculiar rancid odour, and a faintly bitter taste. On examination it gave the following results:—

	Crude Fat.	Refined Fat.
Specific gravity at 99°/15° C.	0·887	--
Acid value	26·5	Nil.
Saponification value	255·0	183·0
Iodine value	65·4	33·7
Hehner value	90·9	—
Titer test	37° C.	37·6° C.

The fat extracted from the kernels possessed a high acid value, and darkened in colour when treated with alkalis. Consequently it would have to be refined before being used for soap-making. The only satisfactory method of accomplishing this is to treat the fat with alkalis, which involves the loss of all the free fatty acids. The refined product thus obtained, the constants of which are given in the second column of the table, is a clear, pleasant-smelling, butter-yellow fat, suitable for soap-making. The firm of soap-makers who examined these nuts for the Imperial Institute stated that the heavy loss involved in refining the oil renders it doubtful whether the nuts could be successfully utilised commercially, but as the kernels are very rich in fat it is possible that it would be worth while to make use of them, especially if they are obtainable in very large quantities at a low cost.

"*Mace.*" This consisted of flat, dark, orange-brown, oily pieces, ¼ to 1¼ inch long, resembling ordinary "mace" in form, but smaller, darker in colour, and devoid of aroma. The taste was oily, bitter and acrid. The material yielded to solvents 57·04 per cent. of oil. This was of dark, orange-red colour, fluid and translucent in thin layers at first, but on standing it deposited a considerable quantity of a semi-crystalline substance. It developed a deep violet colour when treated with alkalis.*

Specific gravity at 99°/15° C. .	0·866
Acid value	10·7
Saponification value	214·0
Iodine value	77·45
Hehner value	91·2
Titer test	35° C.

Owing to the dark colour of the oil, which can only be decolorised satisfactorily by treatment with alkali, involving the removal of the large amount of free fatty acid present, it seems unlikely that this "mace" can be used commercially as a source of oil. The product is devoid of aroma, and cannot therefore be used as a substitute for true mace.

PENTADESMA BUTYRACEA KERNELS AND FAT.

SIERRA LEONE.

A small sample of this fat received in July, 1908, from Sierra Leone, consisted of pale, greyish-coloured, granular fat, with a slight odour like that of Shea butter. The fat contained a good deal of suspended impurity, and after filtration and cooling had a greenish-yellow tinge.

Specific gravity at 100°/15·5° C. ...	0·859
Acid value	3·6
Saponification value	190·1
Iodine value	41·8
Titer test	50·7° C.
Hehner value	95·0
Unsaponifiable matter	1·7
Reichert-Meissl value	Nil.

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* This substance might be included more appropriately with the liquid or semi-liquid non-drying oils, but it is convenient to place it near the Pycnanthus seeds from which it is derived.

From its appearance and chemical constants it seems possible that this fat might be used for the manufacture of edible fats; but practical trials would be necessary to determine this. If unsuitable for the above purpose it might find a market for candle manufacture, in which case, however, its value would not be so high. If available in large quantities this fat would no doubt be saleable in this country, but technical trials on a large scale would have to be made in order to ascertain its commercial value definitely.

SOUTHERN NIGERIA.

A small supply of kernels of *Pentadesma butyracea* was received from Southern Nigeria in April, 1911. It consisted of large brown kernels, irregular in shape and dirty pink to brown internally. The kernels were very moist when received, and on drying in the air they lost about 34 per cent. of their original weight. The air-dried kernels averaged 12 to 13 grams each in weight, and then contained 10·6 per cent. of moisture and yielded 40 per cent. of fat.

The fat was of a pale yellow colour and had a pleasant smell and taste.

Specific gravity at 100°/15·5° C.	0·857
Acid value	3·1
Saponification value	186·0
Iodine value	46·5

A sample of the kernels was submitted to the firm who had applied to the Imperial Institute for information regarding the possibility of obtaining commercial supplies. They reported that samples of *Pentadesma butyracea* kernels which they had examined showed considerable variation in the yield of fat, largely owing to imperfect drying and differences in the degree of ripeness. They also stated that the fat is highly coloured and needs refining before it can be used to advantage in soap-making, whilst the residual cake is of no value as a feeding-stuff for cattle. In view of these facts they considered that the probable value of *Pentadesma butyracea* kernels would be £8 to £10 per ton in the United Kingdom, if imported in good, dry condition.

Other samples of *Pentadesma butyracea* kernels received at the Imperial Institute from British West Africa have yielded much smaller quantities of fat than the sample just described, thus confirming the manufacturers' statements that the kernels are variable in quality. In preparing the kernels for export it is desirable that only mature seeds should be collected and that the kernels should be thoroughly dried in the sun before being shipped.

SALVADORA PERSICA SEEDS.

SUDAN.

S. persica, L., is a diffuse shrub or small tree belonging to the natural order Salvadoraceae, which is found in a wild state thoughout the Sudan, where it is known as "mustard tree."

The seeds received at the Imperial Institute were round, averaging about 0·15 inch in diameter, with thin shells of greyish colour, in many cases slightly mottled with brown. The kernels, which were bright yellow, possessed an unpleasant, bitter taste. The seeds yielded 44·6 per cent. of hard, bright yellow fat, with a faint, slightly unpleasant odour.

The fat was examined with the following results, compared with that from the seeds of *S. oleoides* from India:

	Present sample of *S. persica* seeds.	Seeds of *S. oleoides* from India.*
Specific gravity at $\frac{99° C.}{15° C.}$	0·867	0·908 (at 50° C.)
Acid value	9·3	11·3
Saponification value ...	245·2	242·4
Iodine value	5·9	7·5
Titer test	30·4° C. (approx.)	40° C.
Melting point	38° C.	41° C.

The sample of the seeds was too small for commercial valuation. It may, however, be pointed out that the hardness and high melting-point of the fat render it suitable for the manufacture of candles, and if its unpleasant odour and taste could be removed by purification on a commercial scale it might possibly be employed in the preparation of vegetable butters and "chocolate fats."

In the Indian *Agricultural Ledger*, 1908, No. 1, *S. persica* and *S. oleoides* are considered to be distinct species, but in the *Index Kewensis* they are regarded as identical. The fat extracted from the present sample of seeds resembles that described in the *Agricultural Ledger* as the fat of *S. oleoides*; and as the botanical identity of the Sudan plant would therefore be of interest, specimens have been requested for determination.

"CHEYI" SEED.

NORTHERN NIGERIA.

The name "Cheyi" is applied by the natives of Northern Nigeria to *Polygala butyracea*, Heck., a herbaceous plant occurring commonly in tropical West Africa. The seeds of this plant contain a valuable fat which can be utilised for edible purposes, whilst the stems yield a fibre which is used by the natives for making fishing nets, cloth, thread, &c. A sample of the seed from Northern Nigeria has been examined.

The sample consisted of flat, oval seeds, about $\frac{1}{5}$ inch long and $\frac{1}{10}$ inch broad, brownish-black externally and greenish-yellow within. Some husks and other extraneous matter were present. The seeds yielded 37·9 per cent. of soft, yellowish fat, which possessed a pleasant taste and no distinctive odour.

The fat was examined with the following results, compared with those previously recorded for "Cheyi" fat:

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* Hooper (*Indian "Agricultural Ledger,"* 1908, *No.* 1).

	Present sample.	Results previously recorded.
Melting-point ...	36° C.	—
Specific gravity at $\frac{100^\circ \text{C.}}{15{\cdot}5^\circ \text{C.}}$	0·866	—
Acid value	1·24	11·4
Saponification value ...	251·0	253·0
Iodine value	52·5	49·4
Titer test	37·85° C.	—
Hehner value	85·6	—
Reichert-Meissl value	45·6	45·5

The fat contained 0·55 per cent. of unsaponifiable matter.

Samples of the seeds were submitted for valuation to makers of edible fats and to oil-seed crushers, who furnished the following reports:—

(1) The makers of edible fats were of opinion that "Cheyi" fat would be very suitable for their purposes if the seeds arrived in the United Kingdom in good condition, and were proved to contain no poisonous constituents. On the basis of the yield of fat, they valued the seeds at about half the price of copra, which is now selling in the United Kingdom at £27 15s. to £29 10s. per ton (M[illegible] [illegible]).

(2) The oil-seed crushers also regarded the seed and fat as likely to be of considerable commercial value. They were of opinion that the fat should eventually realise a good price for edible purposes. Assuming that the residual cake would be suitable for feeding cattle, a point that will have to be determined by further examination and trial, they considered the seed to be worth at least £12 per ton in the United Kingdom, and expressed a desire to receive a trial consignment of 100 tons, at this price, as a commencement.

GORLI SEEDS

Sierra Leone.

Two samples of this seed from Sierra Leone were received in June and August, 1908. A specimen of the plant was forwarded to the Imperial Institute in July, 1908, and this was submitted to the Royal Botanic Gardens, Kew, where it was identified as *Oncoba echinata*, Oliver (N. O. Bixaceae). The samples of seed were as follows:—

No. 1.—This consisted of small, rather irregularly-shaped seeds, from ¼ to ⅜ inch long, and [illegible] to [illegible] inch wide at the broadest part. The average weight of a single seed was 0·06 gram. Each seed was enclosed in a stiff brown seed-coat. Internally, the seeds were white, waxy in appearance, and soft, but they did not yield visible oil when squeezed with a knife. They possessed a bland oleaginous taste, but when chewed left a faint peculiar after-taste.

No. 2.—These seeds did not differ materially from those of sample No. 1 in appearance, but they were slightly darker in colour and had a somewhat mouldy odour.

The seeds were analysed and gave the following percentage results:—

	Sample 1. *Per cent.*	Sample 2. *Per cent.*
Moisture	5·8	5·8
Fat	46·6	46·6
Crude proteins	17·5	18·1
Consisting of—		
True proteins	11·3	10·2
Other nitrogenous substances	6·2	7·9
Soluble carbohydrates	*Nil.*	*Nil.*
Starch, &c.	11·8	12·1
Crude fibre	15·6	14·7
Ash	2·7	2·7

As the seeds contained so large a percentage of fat, it was considered advisable to submit this constituent to detailed investigation. It was a hard white crystalline fat, possessing a peculiar odour. The results of its examination were as follows:—

	Fat from Sample No. 1.	Fat from Sample No. 2.
Specific gravity at 15·5° C.	0·898	0·896
Acid value	4·5	22·1
Saponification value	192·4	193·9
Iodine value	99·7	96·8
Titer test	57·8° C.	57·8° C.
Hehner value	96·5	96·5
Reichert-Meissl value	*Nil.*	*Nil.*
Unsaponifiable matter	1·6	1·3

The higher acid value of the fat from sample No. 2, and the variations of the other constants from those of No. 1, are probably due to the fact that the seeds of sample No. 2 were somewhat mouldy. The constants of the fat from sample No. 1 are therefore probably the more normal. The fat yielded a hard soap of satisfactory appearance but possessing the persistent odour of the fat itself. The fatty acids, of which the fat is composed, consist of a solid, crystalline acid (chaulmoogric acid), about 87·5 per cent., and unsaturated liquid acids, about 12·5 per cent. (For further particulars see a paper by Dr. E. Goulding and Mr. N. C. Akers, of the Imperial Institute, *Proc. Chem. Soc.*, 1913, **29**, 197.)

Chaulmoogric acid has been found to induce vomiting in certain animals, and it is therefore evident that neither the fat nor the cake left after expressing it could be employed safely as food. The fat might be of value, however, for soap or candle manufacture, but no definite opinion can be expressed on this point until technical trials have been made.

"TAI FUNG CHI YAU" OIL.

HONG KONG.

This oil, which is said to be produced in Kwangsi Province, was received for examination from Hong Kong in July, 1911. It was cloudy, yellowish-brown in colour, and became semi-solid on standing.

The results of chemical examination of the oil are shown in the following table:—

—	Present sample.	Oil of *Gynocardia odorata.*	"Lukrabo" oil from *Hydnocarpus anthelmintícus*
Specific gravity ...	0·956 at 15·5° C.	0·927 at 25° C.	0·952 at 25° C.
Acid value	37·6	—	-
Saponification value ...	192·0	199·6	208·0
Iodine value	86·5	152·0	82·5

According to information supplied by the Superintendent of the Botanical and Forestry Department in Hong Kong, this oil is said to be derived from *Gynocardia odorata*. The foregoing results, however, show that it does not resemble the oil of *G. odorata* (Power and Barrowcliff, *Trans. Chem. Soc.*, 1905, **87**, 898), but is more like that of *Hydnocarpus anthelminticus* ("Lukrabo" oil), which is known, according to Power and Barrowcliff, as "Ta fung tsze" (*Trans. Chem. Soc.*, 1905, **87**, 893). The present sample, moreover, is optically active, whereas *Gynocardia* oil is not. The oil under report thus appears to be derived from *Hydnocarpus anthelminticus*, or possibly some closely allied species. In the United Kingdom the oil would only be suitable for soap-making, and it is not worth consideration for this purpose unless large quantities are available cheaply. Hydnocarpus oils were recently imported to Europe, and unfortunately used for the preparation of edible fats, and gave rise to several cases of poisoning (see *Bulletin of the Imperial Institute*, 1911, **9**, 406).

MARGOSA SEED (*Melia Azadirachta*).

INDIA.

A small consignment of Margosa seed was forwarded to the Imperial Institute by the Officiating Reporter on Economic Products in September, 1911. It was stated to have been collected in the Rae Bareli District of the United Provinces.

The consignment consisted of unshelled seeds, each composed of a thin woody shell and a single soft oily kernel. The seeds had undergone a considerable amount of fermentation during transit from India, and most of the kernels were mouldy on arrival, whilst a fair proportion were decomposed. The kernels were mostly very dark brown internally, and had the odour of garlic, which is characteristic of Margosa kernels.

The consignment was forwarded to a firm of soap-makers who had expressed a wish to carry out technical trials with Margosa seed. After making a detailed examination of the seed the firm furnished the following report.

The seeds consisted of shell, 55·3 per cent., and kernel, 44·7 per cent. The kernels were found to have the following percentage composition.—

Fat	**48·90***
Moisture	**5·12**
Proteins	**26·67**
Carbohydrates	**12·24**
Ash	**4·28**
Woody fibre	**2·79**

With reference to the yield of fat, it may be stated that the Margosa kernels from Ceylon referred to below yielded 59·25 per cent. of fat, equivalent to a yield of nearly 31 per cent. on the whole seeds. The Ceylon kernels were, however, in much better condition than those from India.

The fat from the Indian seeds was of soft consistence. When extracted by a solvent from the kernels it was yellowish, but when obtained by crushing the entire seed it was dark reddish-brown. The fat obtained by the latter method was found to have the following constants:—

Saponification value		191·80
Free fatty acids, expressed as oleic acid	per cent.	42·68
Unsaponifiable matter ..		0·22
Glycerine	per cent.	5·64

The fatty acids were examined with the following results:—

Specific gravity	0·8578
Iodine value	63·81
Titer test	35·70° C.

The crude expressed fat furnished a soap of inferior brown colour.

The manufacturers stated that the smell of garlic given off by the seeds was almost intolerable when they were heated before being crushed, and would render it quite impossible to express the fat from these seeds on a large scale in any oil-mill situated in a town. They added that the oil on account of its odour would command only a relatively low price, unless the smell could be removed by treatment with superheated steam or otherwise.

CEYLON.

A supply of Margosa seed was forwarded to the Imperial Institute by the Secretary of the Ceylon Agricultural Society in February, 1911.

This consignment consisted of unshelled seeds, each composed of a thin woody shell and a single soft oily kernel. The seeds were in very good condition on arrival at the Imperial Institute and showed no signs of mouldiness or "heating." The kernels were yellow internally and had the odour of garlic, which is characteristic of Margosa kernels.

The consignment was forwarded to the firm who carried out the trials with the Indian seed referred to above. After making a detailed examination of the seed the firm furnished the following report:

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* Equivalent to a yield of about 23·5 per cent. on the whole seeds.

The seeds consisted of shell, 54·2 per cent., and kernel, 45·8 per cent. The kernels were found to have the following percentage composition:—

Fat	59·25*
Moisture	4·65
Proteins	20·53
Carbohydrates	9·10
Ash	3·44
Woody fibre	3·03

The fat was of soft consistence. When extracted by a solvent from the kernels it was yellowish in colour, but when obtained by crushing the entire seed it was dark greenish-brown. The fat obtained by the latter method was found to have the following constants:—

Saponification value		193·90
Free fatty acids, expressed as oleic acid	per cent.	5·37
Unsaponifiable matter		0·34
Glycerine	per cent.	9·61

The fatty acids were examined with the following results:—

Specific gravity	0·8569
Iodine value	66·70
Titer test	40·80° C.

The crude expressed fat furnished a soap of inferior yellowish-brown colour. After refining, the fat was lighter in colour, and gave a fair, dull greenish-yellow soap. The colour of the fat and of the soap made from it are, however, very poor.

These Ceylon seeds, like those from India, also gave off an intolerable odour of garlic when heated as a preliminary to the expression of the fat.

Remarks.

It will be seen from the above results that the fat expressed from these Margosa seeds from India and Ceylon was of poor quality for soap-making purposes, chiefly on account of its dark colour and very unpleasant odour. A further examination of the fat was made at the Imperial Institute to ascertain whether the odour could be removed by any simple process, but without success. It seems unlikely, therefore, that a market can be found in Europe for Margosa seed.

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* Equivalent to a yield of about 31 per cent on the whole seeds

VEGETABLE WAXES.

The most important vegetable wax of commerce is Carnauba wax, obtained from the leaves of a palm, *Copernicia cerifera*, Mart., indigenous to tropical South America. This wax is prepared by cutting the leaves before they are fully open, drying these in the sun and brushing or scraping off the wax. The latter is then thrown into boiling water and melted.

The carnauba wax of commerce is a hard, brittle, yellowish or brownish-grey substance, and is used in the manufacture of candles, polishing-pastes, paper varnishes, phonograph records, electric cable coverings, &c.

The wax is shipped from Ceara, Pernambuco, and other Brazilian ports, principally to Germany, the United Kingdom, and the United States.

The present market price of the wax is about 157 shillings per cwt. (May, 1913), but the price is liable to fluctuate, owing chiefly to the fact that production is restricted to the northern part of South America.

The value of any new or little known vegetable wax, such as those mentioned below, would depend largely on its suitability for use as a substitute for carnauba wax.

BERRY WAX.

Cape Province.

A sample of this wax was supplied to the Imperial Institute, at the suggestion of the Director, by the Agent-General for Cape Colony, in order that it might be examined and its exact commercial value ascertained.

The sample consisted of a moulded cake of wax weighing 5½ lb. In its general characters the wax was similar to the material usually known as Myrtle wax, which is derived from *Myrica cerifera*. The Cape berry wax is probably derived from one or other of the several species of Myrica growing in South Africa, which include *M. quercifolia*, *M. cordifolia*, *M. laciniata*, and *M. serrata*.

The following table gives the constants of this wax as ascertained in the Scientific and Technical Department of the Imperial Institute, with the figures previously recorded for myrtle wax for comparison. It will be seen that the figures correspond very closely.

	Cape berry wax.	Myrtle wax.
Specific gravity at 99° C....	0·8741	0·875-0·878
Acid value	4·09	—
Saponification value ...	211·1	205-217
Iodine value	1·06	1·95-3·9
Mean molecular weight of fatty acids	236·1	243
Melting-point of wax ...	40·5° C.	40·8° C.
Melting-point of fatty acids	47·5° C.	47·5° C.

These results indicated that the wax might be found useful by soap-makers, and possibly for the manufacture of candles, although it appeared that the comparatively low melting-point of the fatty acids might render the material unsuitable for the latter purpose.

Samples of the wax were submitted to two firms of manufacturers for valuation. One of these reported that the wax was not suitable for candle-making, but that it yielded a hard white soap. They wished to have a few hundredweights for trial, and estimated its value at two-thirds to three-quarters the price of ordinary beef tallow, *i.e.*, from 22*s.* to 24*s.* a cwt at that time (December, 1906).

The second firm, after inspecting the sample and having been informed of the results of its examination at the Imperial Institute, requested that a trial consignment of 10 tons of the wax might be obtained at a price not to exceed £29 per ton net, c.i.f. Liverpool. It proved impossible, however, to obtain the quantity required for the trial consignment owing to the absence of any organisation for collecting the wax at the proper season. From information subsequently received there is no doubt that large quantities of the wax will be available, provided that the collection of the material is carried on continuously during the season, and since then consignments have been sold at intervals in London.

RAPHIA WAX.

MADAGASCAR.

In a communication made to the Paris Academy of Sciences in December, 1905, Professor M. H. Jumelle, of Marseilles, drew attention to a vegetable wax, prepared by the natives in certain districts of Madagascar, from the leaves of the raphia palm (*Raphia Ruffia*), well known as the source of the "bass" used by gardeners for attaching plants to stakes. A fuller account of the preparation of this material was given in the *Bulletin Economique de Madagascar* (1906, **6**, 48). As it appeared, from the first accounts published, that this product might be of some economic value, the Director of the Imperial Institute applied to H.M. Consul at Tamatave for samples of the wax, and these were supplied early in 1907. The wax has been examined, and submitted for technical trial to manufacturers.

Raphia bass consists of the epidermal portion of the upper side of the leaf of the raphia palm. When the leaf opens out, the two surfaces which have been in contact in the young stage form the upper surface of the leaf. This has a glossy epidermis, which, on being stripped off, forms the bass. It is on the dull under surface of the leaf that the wax occurs as a whitish layer or bloom, readily detachable by rubbing lightly with the finger.

It is from the residues of the leaves left after the extraction of the bass, that the wax has, up to the present, been obtained. These residues, called by the natives "Taimbontgona," are available in large quantities in the neighbourhood of the raphia groves which have been worked for bass. They are spread out to dry on cloths in the open air, sheltered from the wind, as even a slight breeze is sufficient to blow away much of the light waxy matter. The drying usually takes from two to four days, and at the end of that time a white pellicle is apparent on the under surfaces of the leaves. It is then only necessary to shake the leaves or to rub them between the hands to cause the waxy matter to detach itself, mostly in the form of powder or fine dust. The powder is collected, sifted from foreign material, and placed in boiling water, when the wax melts and floats to the surface whilst any earthy impurity settles to the bottom. The liquefied wax is then transferred to a receiver, where it is allowed to cool and solidify. The product thus prepared is yellow to dark brown in colour, rather harder and more brittle than beeswax.

The following quantities are given as the yields of bass and wax in an experimental extraction of these products in Madagascar. The experiment was made on ten raphia palm leaves of medium size (3½ to 4½ metres in length).

	Kilos.
Total weight of leaves	104·5
Weight of dry bass obtained	4·6
Weight of dry residues (less the ribs of leaves)	11·0
Weight of wax after preparation . .	0·78

In this experiment the yield of wax was equal to 0·75 per cent. of the weight of leaves used, and to about 17 per cent. of the weight of dry fibre extracted. In practice, however, it would be lower, and possibly equal to about 10 per cent. of the weight of fibre.

Professor Jumelle showed that in many respects this product resembles the carnauba wax of commerce, obtained from *Copernicia cerifera*. It has approximately the same melting point (83° C.), and behaves in the same way towards various solvents. Raphia wax has been subjected to a more detailed examination by Professor Haller and M. Desende. The results of these investigations indicate that although in physical properties raphia wax resembles carnauba wax to some extent the two differ considerably in composition.

Two samples of the raphia wax were received at the Imperial Institute. The first consisted of a solid cake weighing 33 grams.

It was yellowish-brown in colour for the most part, but greyish at the edges, and was sufficiently brittle to powder in a mortar.

The second sample was larger, and consisted of two cakes weighing together eight pounds. The lower part of one of these cakes contained a large quantity of sandy or gritty impurity due to careless preparation. Only the upper portion of this was taken for chemical examination.

The results are given in the following table, which also includes, for the purpose of comparison, the corresponding values for carnauba wax and beeswax.

—	Raphia wax. 1	Raphia wax. 2	Carnauba wax.	Beeswax.
Specific gravity at $\frac{99^\circ\ C.}{15 \cdot 5^\circ\ C.}$	0·836	0·832	0·842	0·820
Acid value	4·9	6·5	3·4–7·0	19–21
Saponification value ..	51·3	50·3	79–84	90–99
Iodine value...	7·68	10·7	13·5	8–11
Melting-point of wax ...	82° C.	83° C.	83°–86° C.	63–65° C.

Results of Technical Trials.

The results of the comparative examination showed that the raphia wax agreed closely in physical characters with carnauba wax, and it was considered likely that it might be used for the same purposes, such as the manufacture of polishes, candles, &c.

A firm of boot-polish manufacturers, who were consulted on this point, were at first inclined to view the product favourably, and asked for a larger sample for trial. Unfortunately the second large sample received at the Imperial Institute, as indicated above, contained a good deal of gritty impurity, and this the manufacturers reported rendered the material unsuitable for their purpose.

A firm of candle and soap manufacturers who were also consulted, reported that in some respects the material possessed the qualities of certain waxes already on the market, and although they took exception to the inherent "oiliness" and the dark colour of the wax, they expressed their willingness to purchase a small consignment at the rate of £40 per ton, for trial on a large scale. Enquiries made by H.M. Consul at Tamatave as to the possibility of obtaining commercial supplies of the wax, indicate that a price of £40 per ton would not cover the cost of collecting, preparing, and shipping the wax, and that the latter cannot be produced at present for less than £80 per metric ton f.o.b. Tamatave (Feb. 1908).

ANIMAL OILS.

FISH OILS.

These oils are obtained from the bodies of many kinds of fis such as herrings, sardines, etc.; the bodies of fish yielding liv oils, *e.g.*, cod, do not as a rule contain any appreciable amount o oil.

Fish oils are prepared either from whole fish or from the refus from canneries and curing factories, by boiling and pressing th fish or sometimes by extraction with solvents from dry fish.

The fish oils resemble the vegetable oils in consisting almos entirely of glycerides but frequently contain clupanodonic aci which has not been detected in vegetable oils; they usually hav a high iodine value.

All fish oils are liable to be dark coloured and malodorous owin principally to the rapidity with which the fish deteriorates befor the preparation of the oil, but since the advent of rapid transi in steam trawlers and also owing to improved methods of preparation fish oils can now be obtained of paler colour and less offensive smell. Many attempts have been made to remove the fish smell and so render the oils fit for edible use but so far withou success although it seems possible that the recently introduce process of hardening glycerides by hydrogenation in presence o catalysts (nickel, etc.) may effect this.

The residue remaining after the removal of the oil finds a read market as a manure under the name of fish guano and the bes grades are also used to some extent for cattle feeding.

Fish oils are chiefly used in leather dressing and also in th manufacture of cheap paints, in soap-making and for the adulteration of cod liver and other oils. One of the most importan fish oils is "menhaden oil" which is prepared in large quantitie on the Atlantic coast of North America.

INDIA.

The preparation of sardine oil forms an important part of th experimental work of the Madras Government Fishery Department. Hitherto such work has been carried on at the Cannanore Experimental Station, but during 1911-12 it was transferred t the Experimental Station at Tanur, where fish are usually mor abundant. At first crude brown oil only was prepared, but a there is a better market for the finer grades of fish oil new machinery has been installed at Tanur for producing pale coloure oil, for separating the stearin and for refining the oil, whils deodorising experiments are also to be conducted there. The effor of the Department to create a local fish oil industry have bee highly successful; in 1909 there was only one private facto whilst at the beginning of the 1911-12 season between forty an fifty small factories were producing crude brown oil in Malaba and South Canara, and the erection of factories in Cochin an Travancore is probable.

Seven samples of sardine oil and one sample of "stearin" obtained from sardine oil were received from the Madras Government Fisheries in August, 1912. They were as follows:—

1. "Palest oil from Cannanore."—A pale yellow oil, which deposited stearin on standing.

2. "Palest oil without stearin."—This was a bright yellow oil, clear when received at the Imperial Institute, but like the other samples designated "oils without stearin" (Nos. 4 and 6) it deposited stearin to some extent at the temperatures commonly prevailing in Europe, viz., up to 20° C.

3. "Palest oil with stearin."—A yellow oil with a deposit of stearin.

4. "Yellow oil without stearin."—A pale brown oil.

5. "Yellow oil with stearin."—A pale brown viscous oil.

6. "Brown oil without stearin."—Thick brown oil, possessing an unpleasant odour.

7. "Brown oil with stearin."—Dark brown semi-solid oil, possessing an unpleasant odour.

8. "Stearin."—Pale brown, soft fat.

The samples were examined with the results shown in the following table; No. 7 contained about 3·2 per cent. of water which was removed before the constants were determined.

—	No. 1.	No. 2.	No. 3	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Specific gravity at 100°/15° C.	0·878	0·877	0·877	0·877	0·876	0·876	0·875	0·874
Acid value	3·7	2·3	1·8	4·7	7·1	35·0	53·5	9·0
Saponification value...	196	191	191	193	198	199	200	198
Iodine value	154	156	157	159	154	157	157	131

The general characters and constants of these sardine oils indicate their suitability for the usual purposes to which fish oils are applied, viz. leather-dressing and currying, and to a smaller extent for soft soap manufacture, tempering steel, admixture with paint-oils, and jute-batching. The stearin would also be suitable for use in leather manufacture and soap-making.

The various fish oils used in commerce (e.g. cod, herring, menhaden, Japanese sardine and shark liver oils) differ a good deal from one another in physical and chemical characteristics, but they all have a high iodine value. This constant is of great importance, as it indicates the readiness with which an oil will undergo oxidation, a property on which the value of an oil for leather-dressing largely depends.

The principal fish oil used in the leather industry of the United Kingdom is cod oil, commercial specimens of which usually have an iodine value of about 155. It will be noticed that the iodine values of these sardine oils from Madras (viz., 154 to 159) approximate very closely to this figure.

With the exception of the brown oils (Nos. 6 and 7), all the samples furnished low acid values and appeared to have been carefully prepared. The somewhat high acid values of the brown oils would reduce their value for leather-dressing, as such oils are usually regarded as unsatisfactory for this purpose.

ANIMAL FATS.

"GHI" FROM INDIA.

The most important animal fat is butter which consists principally of the fat of cow's milk. In India the fat is freed from water and curd by heating and is then known as "Ghi." The following samples of "ghi" were examined in connection with an investigation into the possibility of manufacturing a substitute for "ghi" from Indian cotton-seed oil (see p. 462).

Most of the "ghi" produced in India is consumed locally but there is a considerable export to the Straits Settlements, Natal, Ceylon and other countries. The total exports of "ghi" from India in recent years are shown in the following table:—

—	1907–8.	1908–9.	1909–10.	1910–11
	Tons.	Tons.	Tons.	Tons
Quantity	2,204	2,150	2,206	2,359
	£	£	£	£
Value...	178,248	161,616	165,543	186,280

Three samples of "ghi," two made from buffalo's and one from cow's milk, were forwarded to the Imperial Institute by the Director-General of Commercial Intelligence in September, 1908. Two of the samples were specially prepared and were stated to be pure "ghi." The third sample, made from buffalo's milk, was said to be representative of the ordinary "ghi" of good quality sold locally.

Description of samples.

No. 1. Labelled "Pure cow's milk 'ghi' at Rs.1-14-0 a seer."

The sample consisted of soft, buff-coloured, solid fat. The portion near the mouth of the bottle had a slight cheese-like odour, the remainder had a strong but not unpleasant smell suggesting that the fat had been over-heated during preparation.

No. 2. Labelled "Pure buffalo's milk 'ghi' at Rs.1-8-0 a seer."

The sample consisted of nearly white fat, softer than No. 1 and having a rather mouldy smell, but otherwise resembling No. 1 in odour.

No. 3. Labelled "Ordinary buffalo milk 'ghi'."

The sample consisted of "ghi," intermediate in colour between Nos. 1 and 2 and of about the same consistence as No. 1. The smell was similar to that of No. 1 but not so marked.

Results of Examination.

The fats contained the following amounts of moisture and curd:—

—	No. 1.	No. 2	No. 3.
	Per cent.	*Per cent*	*Per cent*
Moisture	2·0	0·4	0·5
Curd	0·35	0·0	0·0

The fats freed from moisture and curd were found to have the following constants:—

—	No. 1. Pure cow's milk "ghi."	No. 2 Pure buffalo's milk "ghi."	No. 3. Ordinary buffalo's milk "ghi.
Specific gravity at 100° C./15·5° C.	0·864	0·866	0·864
Acid value...	7·24	5·46	11·1
Saponification value	222	226	224
Iodine value	34·8	34·6	35·0
Titer test of the fat (not the acids)	30·2° C.	29·4° C.	26·1° C.
Reichert-Meissl value	24	31	29

The above results show that there is very little difference between the chemical characters of cow's milk "ghi" and those of "ghi" prepared from buffalo's milk. The samples were all slightly rancid, as the high acid values show. No. 3 was the most rancid. The Reichert-Meissl values of the two samples of buffalo's milk "ghi" are higher than that of the cow's milk "ghi," but they are still within the limit usually allowed for the fat of ordinary cow's milk butter.

ANIMAL WAXES.

BEESWAX.

Beeswax consists of the comb of the common bee (*Apis mellifica*) and other species. It is produced throughout the temperate and tropical regions of the world by wild or domesticated bees and there are large exports from the West Indies, various parts of Africa, South America and elsewhere.

It consists chiefly of "cerotic acid," a mixture of homologous acids, and myricin, a compound of melissyl alcohol and palmitic acid; free melissic acid, myricyl alcohol, ceryl alcohol, hydrocarbons and other constituents are also present in small quantities.

Beeswax is chiefly used in the manufacture of candles and for the preparation of various kinds of polishes.

The Imperial Institute has examined a considerable number of samples of beeswax, principally from British dependencies in Africa, and in addition has supplied a number of memoranda on the preparation and production of beeswax. The whole of this work up to the end of 1909 was summarised in the *Bulletin of the Imperial Institute* (1910, **8**, 24), and that account has been brought up to date and reproduced below, together with summaries of the reports on samples of beeswax made since that date.

PREPARATION OF BEESWAX.

Modern methods of bee-culture, as adopted in most European countries, Australia, the United States of North America and elsewhere, have for their primary object the production of honey, since the latter realises a better price than wax. In former times when bees were kept in "skeps" or boxes a large number of swarms were destroyed annually, and the whole of the comb, after the honey had been extracted, was converted into wax. As one result of the use of movable box hives it is no longer necessary to destroy all the comb, but merely to remove the cell-capping and extract the honey by means of a machine. The empty comb can then be returned to the hive and re-filled. As bees consume a large quantity of honey in order to make wax, the modern bee-keeper effects a considerable saving in this respect by using the same comb several times. This practice, however, withholds a considerable quantity of wax from the market. The modern custom of retailing honey in the comb, owing to the ease with which extracted honey can be adulterated, likewise prevents a quantity of wax from finding its way to the market as such.

In consequence of the inability of European and other countries where modern methods of bee-culture are practised, to meet the increasing demands of manufacturers for this product, the markets have come to depend more and more for their supplies on countries where the wax produced by wild bees is collected and exported. This industry is at the present time attracting a considerable amount of attention, especially in Eastern, Central, and Western Africa, and for that reason it is of interest to give some account of the methods adopted in preparing beeswax for the market.

Wild wax seldom equals the cultivated product in quality, and this is frequently due to careless methods of preparing it for export, and to adulteration. By paying more attention to the few simple details connected with the process of preparing beeswax for export, it would be possible to produce wax from wild bees almost equal in quality to the European article and which would command a similar price on the market.

There are several methods of "rendering" wax, as the process of separating wax from honey and impurities is termed, and in some countries special appliances are in use for this purpose. In many cases, however, these appliances are too delicate or too complicated in structure for native use and in such countries one or other of the following simple methods is recommended.

The melting of beeswax can be effected either by using sun heat, direct fire heat, boiling water or steam. In a melted state beeswax readily separates from such foreign substances as may be contained in it, and owing to its lower specific gravity will float on the surface of the water.

A simple method of rendering wax, and one formerly adopted by bee-keepers in this country and elsewhere, is to extract as much honey as possible from the comb, first by draining and then by pressure in a press of the ordinary copying-press type, and finally by melting it in presence of water, which dissolves out any residual honey which may cling to the pressed wax. While melted, the wax is strained through calico to remove solid impurities, and is finally re-melted over a fire to remove water, after which it is poured into moulds to set. Care is required in carrying out the final melting as burning may occur, and when this happens a dark-coloured wax of low market value is produced.

Another method followed by bee-keepers who have not adopted modern appliances is to place the comb, after the honey has been extracted, in a canvas bag, which is kept below the surface of the water, contained in a copper or other large vessel, by being weighed with stones. If the comb contains "brood" it is allowed to soak in water for twenty-four hours before being placed in the copper, the object being to fill the dry cocoons with water, which will prevent them absorbing the melted wax. The water in the copper is next heated, and as the wax melts it passes through the canvas bag and rises to the surface of the water leaving behind in the bag all solid impurities. The bag is taken out of the copper and squeezed between two pieces of wood to extract as much wax as possible, and the surface of the melted wax in the copper is frequently skimmed to remove scum and other impurities. A cloth is then thrown over the vessel, and the wax and water allowed to cool as slowly as possible. The wax solidifies into a cake, which can easily be removed from the water. On the under side of the cake there is usually a discoloured layer containing impurities, and this is scraped off and worked up with the next batch of crude wax.

The remainder is broken up into small pieces, re-melted and poured into moulds to set. Provided that care is taken (1) not to boil the water too fast or for too long a time, and (2) to prevent burning during the final melting, this method produces clean wax of good colour; but if either of these precautions be neglected it becomes dry and brittle, and of a brownish hue. The outfit required for the foregoing operations is simple and obtainable almost everywhere.

Of the modern appliances for rendering wax one of the simplest is the "Solar wax extractor," which is in common use in the United States, Australia, and elsewhere. This consists of a wooden box with a sloping double glazed lid. Inside the box, and raised some distance from its floor, an inclined tin tray is fixed. The comb is placed on the tray, the lid tightly closed, and the box exposed to the sun. The temperature inside the box rapidly rises, and when it reaches about 147° F. the wax melts and runs off the sloping tray into a vessel beneath, leaving impurities behind, caught by a wire gauze strainer. This appliance is admirably suited to warm countries, and wax obtained by its use is of good quality, and requires no further refining. It is, however, not suitable for rendering comb containing brood or other gross impurities. In treating comb of this description it is best to extract the wax by one of the methods mentioned above, and then to clarify it by means of the "Solar extractor." Most of the other appliances are provided with a screw press by means of which the wax is forced through strainers after being melted by means of hot water or steam.

Production of Beeswax in Africa.

There is at the present time a considerable export of beeswax from various parts of Africa, and in view of the vast extent of forest land in Africa well stocked with wild bees, this trade is capable of expansion. A race of the common hive bee of Europe known as *Apis mellifica*, Linn. var. *Adansonii*, Latr., occurs throughout the African continent from Egypt to West Africa and southwards to the Cape, but with the exception of the Fellaheen of Egypt, few, if any, of the African peoples have domesticated bees.

A number of samples of beeswax have been received at the Imperial Institute from British Colonies and Dependencies in Africa, and as illustrating the generally excellent quality of the material obtainable, the following tabular statement of the results of their examination and valuation may be given (p. 589).

From several of these countries beeswax is exported already, and in all of them bees are stated to be abundant, so that there is room for the development of this industry. It is scarcely worth while to refer in detail to the production of wax in each of these and other African Territories in which this industry is carried on, or is susceptible of development, and in the following pages reference is only made to a few countries in which developments have recently occurred, or in which the industry is specially well organised.

Country of Origin.	Specific gravity at 99°/15.5° C.	Melting-point.	Saponification value.	Acid value.	Ester value.	Moisture.	Ash.	Matter soluble in water.	Matter insoluble in chloroform.	Valuation.	Date of valuation.
		°C.				Per cent.	Per cent.	Per cent.	Per cent.	Per cwt. £ s. d.	
Nyasaland Protectorate.	—	—	—	—	—	—	—	—	—	6 17 6 to 7 0 0	Feb. 1904
Imported to Sudan from Abyssinia.	—	—	—	—	—	—	—	—	—	6 0 0	Oct. 1905
Bahr-el-Ghazal, Sudan.	—	—	—	—	—	—	—	—	—	7 0 0	Mar. 1906
Sudan ...	0·821	66	84·6	20·6	64·0	1·35	0·42	1·20	0·60	..	—
Southern Rhodesia	—	—	—	—	—	—	—	—	—	6 12 6 to 6 15 0	Oct. 1907
Gold Coast Colony	0·829	64·5°	90·8	20·5	70·3	Nil	0·16	0·28	1·10	6 15 0	Dec. 1908
Uganda Protectorate.	0·812	63·2°	92·4	18·6	73·8	0·6	0·08		-	6 12 6	Jan. 1909
Commercial beeswax.	0·822	63°–64	90 to 95	19 to 20	71 to 75	—			-	6 5 0 to 7 0 0	Feb. 1909

German East Africa.

During recent years much attention has been devoted to the subject of beeswax production in German East Africa, and as a result beeswax now ranks high as an article of export from that Protectorate (*Bulletin of the Imperial Institute*, 1910, **8**, 56). In 1909, 199 tons, valued at £23,165, were exported and in 1910, 195 tons, valued at £22,450. It has been observed that wild bees are attracted in large numbers by the flowers of the Ceará rubber tree (*Manihot Glaziovii*) and other cultivated crops. In German East Africa swarms of bees are encouraged to settle, by placing in favourable situations on the plantations, rough hives, consisting of hollow branches or tree trunks, boxes, or cleansed kerosene tins. A piece of honeycomb placed in these receptacles soon attracts a swarm, and when once the bees can be induced to settle they increase rapidly. These rough hives are quickly filled with honeycomb, which is removed at night in the ordinary way, care being taken to leave sufficient honey in the hive to encourage the bees to start building again. The comb containing brood is not taken, and special precautions are observed to prevent the natives from stealing the brood-comb, as they like to eat young bees. To "render" the wax, a modification of a process already described is adopted. The comb containing the honey is broken up, and thrown into a large vessel and carefully melted at a low temperature. The wax separates from the honey, and when both have cooled, the former rests on the latter as a solid cake. This cake is removed, the under surface, which contains impurities, is scraped off, and the remainder broken up into small pieces and melted in the presence of several times its bulk of water. Whilst in a melted state the wax is filtered through a piece of cloth and finally run into moulds. Any vessel may serve as a mould, provided its shape is such that the solid cake of wax can be easily removed.

The honey obtained from the flower of the Ceara rubber tree is unsuitable for food, but is fed to the bees. These eat it greedily, and use it for the production of wax, with which to replenish their hives with comb. It is estimated that a strong swarm of bees will produce from 7 to 11 lb. of wax in a year, and as the cost of collecting and preparing it for export is small there is a good return for the labour and expenditure involved.

Uganda Protectorate.

Quite recently the Agricultural Department of Uganda has taken up the subject of beeswax production in that Protectorate, and two Baganda chiefs have been sent to German East Africa to study the methods followed there, and described above, in the preparation of wax for export. On the return of these chiefs to Uganda, leaflets in English and Luganda setting forth the advantages to be derived from bee-keeping and giving instructions as to the methods of procedure for obtaining wax of good quality, were widely circulated. The men who visited German East Africa were, on their return, sent to various parts of Uganda to give demonstrations to natives in the preparation of wax, and as a result some thousands of hives have been erected and many are occupied. There is reason to believe that in the near future beeswax will form one of the staple exports of Uganda. In 1910-11, 35 cwts., valued at £162, were exported, and in 1911-12, 32 cwts., also valued at £162.

In the supplement to the *Uganda Gazette* for May 15, 1909 Mr. Dawe, of the Uganda Botanical, Scientific and Forestry Department, recommends the use of the old system of skep hives for wild bees. This system is already used by some missionaries in the Protectorate with good results. Native-made baskets inverted and plastered with cow-dung and mud serve as hives, and when the bees swarm a second hive is placed on the top of the first, a small hole in the top of the first hive providing the means of communication between the two. When filled with honeycomb the top hive can easily be removed, and as only the worker bees can pass from the lower hive through the small hole into the upper, no brood comb is formed in the latter.

A leaflet in Luganda describing the skep hive is being published for distribution, and as soon as the advantages of the skep over more primitive hives are recognised, its adoption will, no doubt, become general throughout the country.

East Africa Protectorate.

In this Protectorate the subject of beeswax production for export is also receiving attention, and one of the Baganda chiefs (see above) who visited German East Africa has been loaned to the authorities for the purpose of instructing the natives in the methods to be followed. Considerable quantities have been produced in recent years, as is shown in the following table:—

—	1908–9.	1909–10.	1910–11.
	Tons.	*Tons.*	*Tons.*
Quantity	266	115	195
	£	£	£
Value	29,656	12,957	22,330

Gambia.

Already a large quantity of beeswax is annually exported from the Gambia, the exports for 1910-11 being 230 cwts., valued at £1,274, and 302 cwts., valued at £1,514, respectively. This is collected in the Kommbo and Fogni districts, where there are vast areas of forest land well stocked with bees. The natives collect the wax and sell it in a crude state to European merchants, who clarify it before it is exported. According to a report supplied by the Governor of the Gambia to the Imperial Institute recently, the process of clarification used is as follows: A special building known as the wax-house is provided, and in this is arranged a row of large cooking-pots with a fire-place beneath them. Fixed to the wall near the pots is a screw-press of the ordinary copying-press pattern, but with a box-like receptacle to hold the melted wax. The pots in which the wax is to be melted are half filled with water and the fires lighted. Into these pots the crude wax is thrown after being broken up into small pieces. The water is allowed to boil for about three hours, and the melted wax is then ready for the press. The press receptacle into which the wax is poured measures 21 × 26 × 26 inches, and has a lining of perforated zinc fixed at about half-an-inch from the sides. Space is thus provided for the escape of the wax and water when pressure is applied. A tube leads from the press and conducts the mixture of wax and water to a barrel placed to receive it. By means of a tap at the base of the barrel the water is drawn off from time to time, so that eventually little besides wax remains.

When using the press a layer of grass is placed at the bottom of the receptacle, and this is scalded with boiling water to prevent the wax adhering to it. A second layer of grass is arranged crossways on the first and then a layer of hot water and melted wax is poured over it from the cooking pots. Alternate layers of grass and wax succeed this until the receptacle is full, when pressure is applied by means of the screw. Under pressure the wax is squeezed out and escapes into the barrel, leaving all impurities between the layers of grass. The melted wax is allowed to remain in the barrel for from fourteen to fifteen hours, when it is sufficiently cool to handle, and is poured into moulds previously oiled to receive it.

Production of Beeswax in India.

The beeswax exported from India is the product of three species of *Apis*, namely: *A. dorsata*, Fabr.; *A. indica*, Fabr.; and *A. florea*, Fabr. The wax derived from each of these is practically identical in composition, but differs somewhat from European wax, chiefly in its lower acid value. The collection of wax is carried on here and there throughout India and Burma, mainly by jungle tribes, who gather it from trees and rocks. Besides entering into a number of local industries, there is a considerable amount of beeswax exported mainly to Germany, the United Kingdom, France, Belgium and the Straits Settlements. In preparing the wax the honey is first removed by squeezing the comb between the hands. It is then washed in cold water to further remove honey or other soluble matter contained in it, after which it is placed in a vessel half filled with water and heated over a fire. As a rule no attempt is made to grade the wax before melting, so that comb containing brood, eggs, twigs, leaves, grass, etc., is included in the boiling. These impurities separate from the wax when in a melted condition, and are removed by straining the wax through cotton cloth. On cooling, the wax is made into cakes or balls. A second melting is sometimes given, and turmeric powder is frequently mixed with the wax to give it a bright yellow colour. In a melted state it is poured into vessels containing a little water, which serve as moulds.

The following table shows the total exports of beeswax from India in recent years:—

—	1908-9.	1909-10.	1910-11.	1911-12
	Tons.	*Tons.*	*Tons.*	*Tons.*
Quantity	236	351	428	629
	£	£	£	£
Value	26,406	39,278	49,240	66,159

The following further samples of beeswax have been reported on by the Imperial Institute since 1909:—

NORTHERN NIGERIA.

The seven samples of beeswax which are the subject of this report were forwarded to the Imperial Institute in September, 1910. They were stated to have been obtained from the Lapa and Zungeru districts of the Niger Province.

(1) Weight, 1½ oz. Small pieces of pale, partially bleached wax, free from obvious impurities.

(2) Weight, 8 oz. A thin circular cake of pale yellowish brown wax, showing a few specks of dirt on the under-surface.

(3) Weight, 10 oz. A thin circular cake of pale yellow wax, which had apparently been partially bleached.

(4) Weight, 1 lb. Two thin rectangular cakes of pale yellowish-brown wax, clean on one surface but somewhat dirty on the other

(5) Weight, 3½ lb. Six circular cakes of dark brown wax, somewhat dirty externally but clean within. The material had a "burnt" odour, probably due to over-heating during preparation.

(6) Weight, 4¾ oz. A circular cake of clean brownish-yellow wax, flat on one side and convex on the other, which had apparently been scraped to remove dirt.

(7) Weight, 4 oz. A flat rectangular cake of brownish-yellow wax, showing some dark brownish spots. The centre of the mass was soft and granular.

The following tables show (I.) the amount of impurities in the samples of wax as received, and (II.) the results of the detailed examination of refined wax prepared from the samples at the

Imperial Institute, to which the corresponding figures recorded for other samples of African beeswax are added for comparison:—

I.—*Impurities in Samples of Wax as received.*

—	(1) Per cent.	(2) Per cent.	(3) Per cent.	(4) Per cent.	(5) Per cent.	(6) Per cent.	(7) Per cent.
Moisture ...	0·20	0·09	0·05	0·09	0·64	0·82	1·05
Dirt ...	0·11	0·18	0·05	0·18	0·20	0·33	0·21
Matter soluble in hot water.	0·15	0·13	0·05	0·20	0·20	0·10	0·15
Ash ...	—*	0·03	nil	0·02	0·12	0·02	0·01

* *This sample was too small for this determination.*

II.—*Results of Chemical Examination.*

—	Refined wax prepared from Northern Nigeria Samples.							Samples previously examined at the Imperial Institute.		Samples examined by:— Dietz	Berg	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	From Gold Coast.	From Uganda.	From Angola.	From German East Africa.	From Sierra Leone.
Melting-point	64·5° to 65° C.	63·5° to 64° C.	63° C.	63·5 to 64° C.	63·5° to 64 C.	63·5 C.	64 C.	64·5 C.	63·2 C.	63·5 C.	63·0° to 64·5° C.	64°C.
Acid value ..	—	15·8	19·7	18·7	20·0	15·6	16·3	20·5	18·6	19·6	19·4 to 21·5	21·3
Ester value ...	—	78·0	76·3	76·6	75·3	78·4	77·2	70·3	73·8	73·0	80·7 to 80·9	80·1
Ratio of ester value to acid value.	—	4·9	3·9	4·1	3·7	5·0	4·7	3·43	3·96	3·7	3·75 to 4·16	3·76
Iodine value ..	—	9·3	5·9	5·9	7·5	9·5	8·1	—	—	—	—	—
Weinwurm's test.	Clear	Cloudy	Cloudy	Clear	Clear	Cloudy	Cloudy	—	Clear	—	—	—

It will be seen from Table I. that the samples contained only small amounts of moisture, ash, dirt, and "matter soluble in hot water" (probably a little honey), and they may therefore be regarded as carefully prepared.

The results of the chemical examination, as given in Table II., show that some of these samples of beeswax are slightly abnormal. Nos. 2, 6 and 7 have rather high ester values and somewhat low acid values, and consequently the "ratio" values are higher than the average recorded for pure beeswax, viz., about 3·7 to 4·2. Analyses of genuine beeswax have, however, been published, giving figures widely divergent from those which may be taken as the average, and it is therefore possible that these samples are uncontaminated wax of somewhat different character from the African waxes previously examined. The analytical figures obtained for samples 3, 4 and 5 agree with those recorded for genuine beeswax.

Samples 2, 3, 6 and 7 yield a cloudy solution with Weinwurm's test. This test was originally designed to detect the presence of paraffin wax or other adulterants in beeswax, but it is well known that certain pure beeswaxes respond to the test owing to some slight abnormality in their composition. It is quite possible that the production of a cloudy solution in the present case may be due to a similar abnormality, but probably this would not interfere in any way with the technical application of the material.

The samples, with the exception of No. 1, were submitted to commercial experts, who described and valued them as follows:—

Sample.	*Description.*	*Value per cwt.*
2.	Clean, palish, re-melted ...	£6 17*s*. 6*d*.
3.	Clean, bleached, pale yellow ...	£7 5*s*. to £7 10*s*.
4.	Clean, fair colour, remelted ...	£6 17*s*. 6*d*.
5.	Crude, darkish to fair colour, clean	£6 15*s*.
6.	Clean, palish, re-melted ...	£6 17*s*. 6*d*.
7.	Clean, pale, re-melted ...	£7

On the date of valuation, Jamaica beeswax was quoted in London at £7 5*s*. to £8 2*s*. 6*d*. per cwt., and East African at £6 5*s*. to £6 10*s*. per cwt. (March, 1911). The experts stated that the present demand for beeswax in London is good, and they anticipated that prices will be maintained.

It is understood that large quantities of beeswax are available in Northern Nigeria, and in some cases, *e.g.*, in the Zungeru and Lapai districts, rail transport is already available. In view, therefore, of the good prices which the material would realise in London, and the large demand which exists for beeswax in the United Kingdom, efforts should be made to establish an export trade in the product from the Protectorate.

SUDAN.

The following samples were received from the Sudan in 1911 and 1912:—

No. 1.—"Beeswax from Sennar Province." This consisted of a number of circular cakes, flat on the top and rounded on the bottom surface. The upper portions of the cakes were in most cases clean, and of yellowish-brown colour, but the lower portions were dirty, dark greyish-brown, owing to the settling out of dirt as the wax cooled after melting. The wax could be improved in appearance by re-melting and straining.

An average sample of the wax was found to contain 0·66 per cent. of dirt (matter insoluble in carbon tetrachloride) and 0·24 per cent. of ash. The amount of ash in the wax was normal, but the percentage of dirt was too high.

A sample of the wax was submitted for valuation to commercial experts, who stated that the material was dirty, and in this state might not realise more than £6 7*s*. 6*d*. per cwt., but if fairly clean its value would be £6 15*s*. to £6 17*s*. 6*d*. per cwt. ex warehouse, London (September, 1911).

No. 2.—"Beeswax from the Yei River district." This sample consisted of a ball of wax, somewhat dirty on the outside, pale coloured, opaque, mottled, and free from obvious impurities.

The wax was submitted for valuation to brokers, who stated that the sample was very clean for rough ball, and worth fully £6 12*s*. 6*d*. per cwt., less 2½ per cent. discount, ex warehouse, London (December, 1911). They added that beeswax of this description is easily saleable.

No. 3.—"Beeswax collected near Raga, in the Western district of the Bahr-el-Ghazal Province." This was a portion of a circular cake of pale-coloured wax, about 1¼ in. in thickness, and free from any appreciable amount of dirt except on the exterior. It was of a paler tint than the sample from the Yei River district, and was equally clean.

The wax was submitted to brokers, who valued it at £7 5*s*. per cwt., less 2½ per cent. discount, ex warehouse, London (June, 1912). Consignments of similar wax would be readily saleable.

No. 4.—"Beeswax collected in the Yambio district of the Bahr-el-Ghazal Province." Four samples of this product were submitted as follows:

"*A*.—'Light' or 'clear' as brought in." Irregular lumps of pale brown, unmelted wax containing much honey.

"*B*.—'A' after being boiled down to about ¼ of its original weight." Irregular fragments of yellow wax, about $\frac{1}{16}$ in. thick, covered with mould externally, but clean within.

"*C*.—'Dark' or 'dirty' as brought in." Irregular lumps of dirty, dark brown wax.

"*D*.—'C' after being boiled down to about ¼ of its original weight." Irregular lumps of yellow wax, fairly clean inside, but containing some dirt.

The specimens were examined with the following results:—

	A.	B.	C.	D.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	13·4	0·18	18·9	0·3
Dirt (approx.)	9·5	0·34	12·5	1·3
Water-soluble impurities, *i.e.*, honey, etc. (approx.).	38·0	0·27	49·5	0·7
Wax (approx.) by difference	39·1	99·2	19·1	97·7

The materials represented by samples A and C could not be offered as beeswax in the United Kingdom. It might be possible to sell such products as raw material for the extraction of wax, but it would be very much better to export clean wax prepared as already described (p. 586).

Beeswax represented by samples B and D would be saleable in the United Kingdom, the former being worth about £6 12*s*. 6*d* and the latter about £6 10*s*. per cwt., less 2½ per cent. discount (October, 1912). Slightly higher prices would be obtainable for the wax if it were shipped quite clean in the form of cakes.